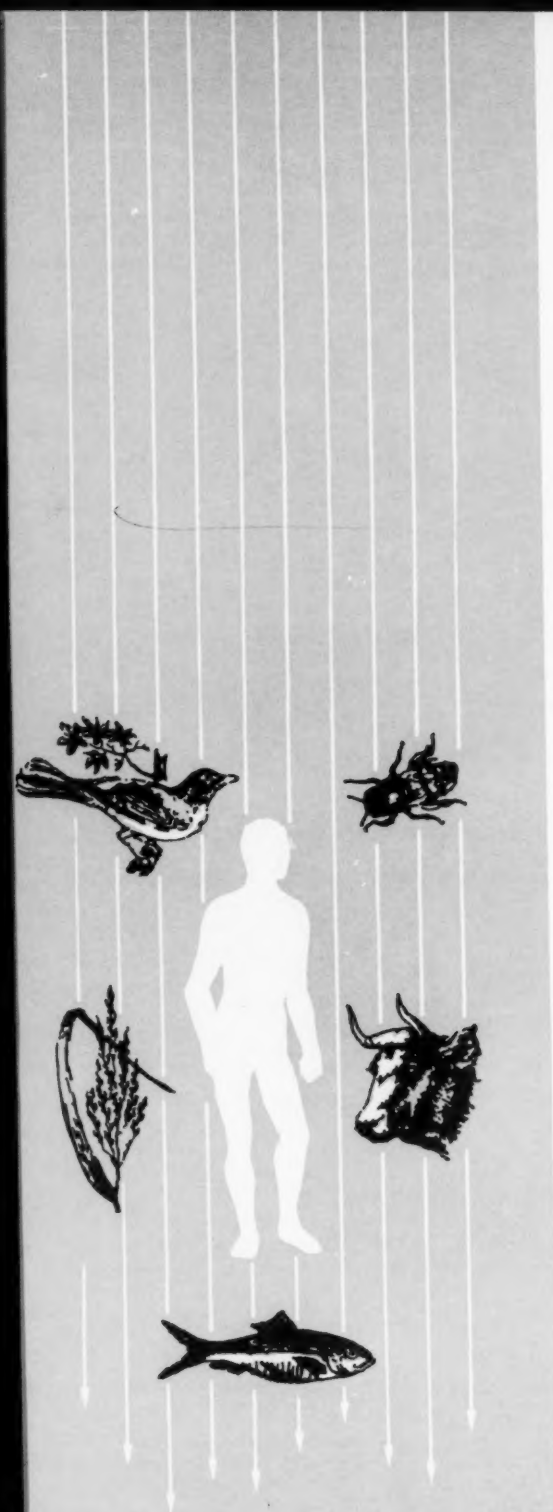

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FEDERAL WORKING GROUP ON PEST MANAGEMENT
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The *Pesticides Monitoring Journal* is published quarterly under the auspices of the Federal Working Group on Pest Management (responsible to the Council on Environmental Quality) and its Monitoring Panel as a source of information on pesticide levels relative to humans and their environment.

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The Monitoring Panel consists of representatives of the Agricultural Research Service, Animal and Plant Health Inspection Service, Extension Service, Forest Service, Department of Defense, Fish and Wildlife Service, Geological Survey, Food and Drug Administration, Environmental Protection Agency, National Marine Fisheries Service, National Science Foundation, and Tennessee Valley Authority.

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FISH, WILDLIFE, AND ESTUARIES

Pesticide Residues in Estuarine Mollusks, 1977 versus 1972—National Pesticide Monitoring Program

Philip A. Butler,[1] Charles D. Kennedy,[2] and Roy L. Schutzmann[2]

ABSTRACT

Bivalve mollusks were monitored for residues of 20 organochlorine and organophosphate pesticides and polychlorinated biphenyls in spring 1977 in 87 of the 181 estuaries routinely monitored on a monthly basis during 1965–72. DDT, the only pesticide detected in 1977, occurred at low levels in one estuary each on the Atlantic and Pacific coasts.

Introduction

In 1965 the U.S. Bureau of Commercial Fisheries initiated a program to monitor shellfish populations for organochlorines. In cooperation with local laboratories, about 180 permanent monitoring stations in 15 coastal states were sampled for any one of 10 species of mollusks monthly. The eastern oyster, *Crassostrea virginica*, was the principal species collected on the Atlantic coast, and *C. gigas* was the species usually monitored on the Pacific coast. The program continued until 1972, but not all areas were monitored for the entire period. About 8,100 samples containing 15 pooled individuals were analyzed. DDT was found in almost all samples. Dieldrin was the next most commonly detected pesticide; residues of endrin, mirex, toxaphene, and polychlorinated biphenyls (PCBs) were detected occasionally. By 1972, there was a clearly defined trend toward fewer and smaller residues of DDT and its metabolites (*1*).

Early in 1977, the U.S. Environmental Protection Agency monitored mollusks at some of the same sites to determine further trends in pollution levels after the 5–7-year lapse.

Materials and Methods

The original cooperating laboratories agreed to collect the new samples. About half the former stations where pesticides had been found consistently a decade ago were monitored again. Single collections of 30 bivalves at each site were made just before or during early stages of the spawning cycle so that tissue lipid levels presumably would approach the maximum.

There were 178 samples; replicate collections were made at 89 stations in 87 estuaries. Depending on the availability, seven species of mollusks were used including the freshwater Asiatic clam, *Corbicula manilensis;* eastern oyster, *Crassostrea virginica;* Pacific oyster, *C. gigas;* Atlantic ribbed mussel, *Geukensia demissa;* northern quahog, *Mercenaria mercenaria;* soft-shell clam, *Mya arenaria;* and blue mussel, *Mytilus edulis*. Oysters were sampled in 63 estuaries, mussels in 14, and clams in 10 estuaries. However, clams are the least satisfactory as biomonitors (*2*).

Two samples of 15 bivalves each were collected at each station. They were shucked but were not drained, and were homogenized in an electric blender. A single aliquot of about 50 g from each pooled sample was preserved with 50 ml reagent grade methanol and mailed in a methylpentene vial to the EPA Pesticides Monitoring Laboratory in Bay St. Louis, Mississippi, for analysis. Analytical procedures, detailed elsewhere (*3*), permitted the detection of 20 organochlorine and organophosphate pesticides and PCBs (Table 1). In the 1965–72 program, samples were screened routinely for only 11 of the more persistent organochlorine pesticides.

Results and Discussion

The salient feature of the 1977 monitoring data was the absence of detectable pesticide residues in 85 of the 87

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TABLE 1. *Compounds detected by chemical procedures used in monitoring mollusks*

Organochlorines	Organophosphates
Aldrin	Azinphosmethyl
Chlordane	Carbophenothion
ΣDDT	DEF
Dieldrin	Demeton
Endosulfan	Diazinon
Heptachlor	Ethion
Lindane	Malathion
Methoxychlor	Parathion
Mirex	Phorate
PCBs	
Toxaphene	
Trifluralin	

NOTE: Lower detection limit is 10 μg/kg for all compounds except endosulfan, 20 μg/kg; methoxychlor and ethion, 30 μg/kg; mirex, PCBs, toxaphene, carbophenothion, and DEF, 50 μg/kg.

estuaries sampled and the complete absence of PCBs. On the Atlantic coast, oysters from two adjacent New Jersey reefs and one reef on the Delaware side of upper Delaware Bay contained DDE. Average residue in the six samples was 33 ± 15 μg/kg. Oysters from reefs closer to the mouth of the estuary did not contain detectable residues. As recently as 1972, every monthly oyster sample on the New Jersey side of the Bay contained about three times as much DDT as did samples collected in 1977, as well as residues of dieldrin and PCBs. The fauna in Delaware Bay were presumably contaminated by the hundreds of tons of DDT sprayed aerially between 1950 and 1966 to control New Jersey marsh mosquitoes (*4*).

On the Pacific coast, bivalves in only one of the 14 estuaries monitored in California and Washington state contained pesticide residues. Replicate samples of blue mussels from Muga Lagoon, about 35 miles north of Los Angeles, contained DDT and its metabolites, TDE and DDE, at the average level of 122 μg/kg. A decade earlier, monthly samples of mussels from this station contained ΣDDT residues of 500–1,800 μg/kg, as well as traces of dieldrin and endrin.

The reliability of these isolated data in documenting the virtual disappearance of pesticide pollution from estuarine water is dependent on knowledge gained from the earlier program of the seasonal aspects of waterborne pesticide pollution. Monthly samples in that study showed that pesticide residues in intermittently polluted areas were typically present in the spring, and, if continuously present, were usually larger in the spring, presumably the result of increased river runoff.

The decline in pollution is emphasized by comparison of the present data with pesticide residue levels and incidence in bivalves from the same estuaries during the final 12 months of the earlier program (Table 2). This table shows the number of stations monitored in each state in 1977 but does not repeat the 1977 residue data.

Since filter-feeding bivalves purge themselves of organic residues within a few weeks in the absence of continuing pollution (*2*), the 1977 data show essentially the disappearance of pesticides from the water mass. However, there is evidence that persistent pesticides have not disappeared entirely from most of these estuarine ecosystems. During 1972–76, yearling fish of several species were monitored in many of the same estuaries from which bivalves were collected in 1977 (*3*). Samples consisted of 25 whole fish captured twice yearly. In 1976, 68 samples or 36 percent of the 190 samples analyzed contained DDT residues at levels up to 2,500 μg/kg; 22 percent of the samples also contained PCBs.

TABLE 2. *Summary of pesticide residues in estuarine mollusks during the final 12 months of the 1965–72 program in those estuaries re-monitored in 1977*

State	Final 12 Months	No. of Stations	No. of Samples	% of Samples with DDT	Arith. Mean of DDT, μg/kg	Other Residues Detected [1]	Species Monitored [2]
Alabama	1968–69	2	10	100	102	D	2
California	1971–72	14	68	96	81	D,E,P	1,3,4,7
Delaware	1968–69	5	58	74	44	D	2,4,5
Florida	1968–69	6	61	85	308	D	2
Georgia	1971–72	5	60	20	14	D,T,P	2
Maine	1969–70	5	36	14	29	—	6,8
Maryland	1969–70	6	11	64	25	D	2
Mississippi	1971–72	3	30	63	31	—	2
New Jersey	1971–72	3	15	100	74	D,P	2
New York	1971–72	6	67	88	40	D	2,5,7
North Carolina	1971–72	9	88	35	46	D	2
South Carolina	1968–69	7	83	37	24	D,M	2
Texas	1971–72	6	56	73	72	D,E,T,P	2
Virginia	1971–72	6	24	96	36	D,P	2
Washington state	1967–68	6	72	18	20	—	3

[1] D=dieldrin, E=endrin, M=mirex, P=PCB, T=toxaphene.
[2] 1, *Corbicula manilensis*, Asiatic clam; 2, *Crassostrea virginica*, eastern oyster; 3, *C. gigas*, Pacific oyster; 4, *Geukensia demissa*, Atlantic ribbed mussel; 5, *Mercenaria mercenaria*, northern quahog; 6, *Mya arenaria*, soft-shell clam; 7, *Mytilus edulis*, blue mussel.

The residues in fish are probably the result of storage and recycling of synthetic pesticides in different links of the food web. The filter-feeding mollusks present a more realistic picture of the current input of pesticides into the marine environment. However, bivalves must be monitored more frequently to reflect fluctuating pollution patterns.

Acknowledgment

The authors are grateful to the staffs of the many federal, state, and university agencies, all of whom participated enthusiastically in this project.

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Chlorinated Insecticide and PCB Residues in Fish and Mussels of East Coastal Waters of the Middle and North Adriatic Sea, 1974–75[1]

Mladen Picer, Nena Picer, and Marijan Ahel[2]

ABSTRACT

Concentrations of chlorinated pesticides and polychlorinated biphenyls (PCBs) were determined in mussels (Mytilus galloprovincialis) *and goby fish* (Gibius *sp.*) *collected in four areas located in eastern coastal waters of the middle and north Adriatic Sea. Most samples were collected in early spring and late summer of 1974 and 1975.*

The compounds p,p'-*DDT*, p,p'-*DDE*, p,p'-*TDE, and PCBs were detected most frequently. In about 60 percent of the samples dieldrin was also detected.*

Average wet-weight concentrations of ΣDDT and PCBs in mussels from the four areas sampled were: Istrian coast, 65 and 76 ppb; Rijeka Bay, 58 and 75 ppb; Zadar, 36 and 128 ppb; Losinj Island, 167 and 133 ppb. Average concentrations in fish samples were: Istrian coast, 124 and 144 ppb; Rijeka Bay, 37 and 82 ppb; Losinj Island, 166 and 157 ppb. Dieldrin concentrations were in the low ppb range.

Although major Italian rivers discharge chlorinated hydrocarbons into the north Adriatic, sampling of biota from Istrian coastal waters indicates no significant effect on the pollution level. However, waste waters from small coastal settlements evidently do contribute significantly to chlorinated hydrocarbon contamination of that ocean.

Marine samples from Losinj Island had high chlorinated hydrocarbon concentrations, indicating uptake of pollutants from the north Adriatic.

Introduction

Many chlorinated insecticides and industrial aromatic chlorinated hydrocarbons such as polychlorinated benzenes, naphthalenes, biphenyls, and terphenyls are extremely resistant to degradation in the environment (*12, 22*). On the other hand, toxicological and other harmful effects of these compounds on aquatic and terrestrial ecosystems are well documented (*2, 8*). Thus worldwide research has focused on the occurrence and fate of chlorinated hydrocarbons in terrestrial, freshwater, and marine ecosystems (*4, 11, 19*).

The most delicate and endangered parts of world oceans are semiclosed formations such as the Mediterranean Sea and the Adriatic Sea. The Adriatic Sea is shallow and small, and its northernmost extension, the Gulf of Trieste, lies virtually in the heart of Middle Europe; hence it is among the most jeopardized marine ecosystems in the world (*18*).

As part of the United Nations Development Program assisted project "Protection of the Human Environment in the Yugoslav Adriatic Region," chlorinated hydrocarbons were measured in mussels (*Mytilus galloprovincialis*) and in some benthic fishes (*Gobius* sp.) of the eastern coastal water of the north and middle Adriatic and near Losinj Island (Figure 1).

The mussel was chosen for monitoring chlorinated hydrocarbons because it is a well-known filter feeder recommended for monitoring many organic and inorganic pollutants (*6*). The goby fish was selected for its restricted living area and high tolerance for polluted seawater, which makes it a logical indicator of polluted marine environments. Other fish species were chosen for their popularity as food among local populations.

By analyzing chlorinated hydrocarbon contamination in mussels and fish from the eastern waters of the north and middle Adriatic, authors hoped to measure regional pollution caused by intensive agricultural and industrial discharges into the northern Adriatic, and local pollution of two nuclei, the Bay of Rijeka and the town of Zadar. Losinj Island south of the Bay of Rijeka was chosen as a clean reference area because it has no significant industry or agriculture and it is not heavily populated.

Sampling and Analysis

Mussels were collected manually or by dredging in intertidal or very shallow water. Soft tissue was removed

[1]Study supported in part by Self-Management Community of Interest for Scientific Research of S. R. Croatia.

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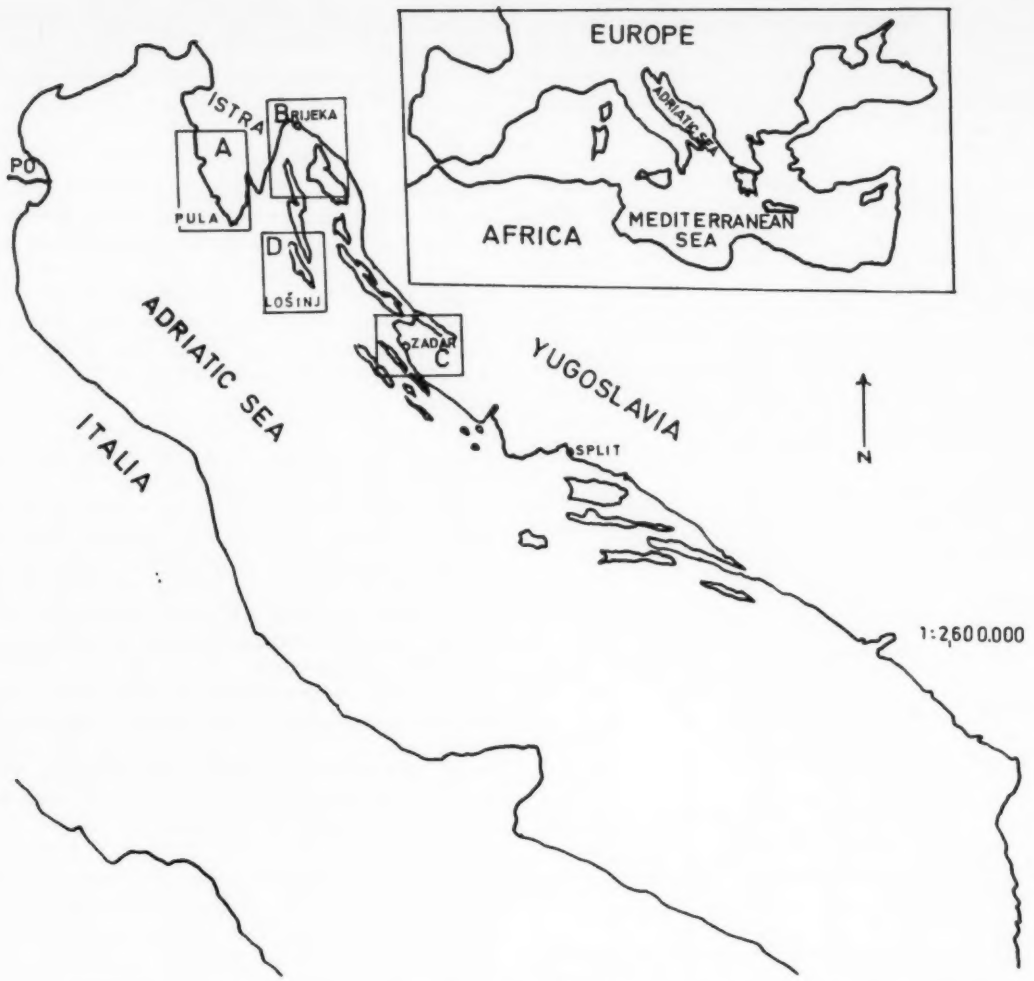

FIGURE 1. *Adriatic Sea, with areas sampled for chlorinated insecticide and PCB residues in marine biota*

from the shell, placed in aluminum foil, and frozen. The foil had been cleaned with redistilled petroleum ether and heated at 200°C for 12 hours. Samples consisted of 20–30 individual animals with shells 3–5 cm long. For the extraction of chlorinated hydrocarbons a subsample of 10 g was taken by a clean scalpel. Sample remains were frozen for analysis.

Goby fish were taken from the sea by angle, placed in clean aluminum foil, and frozen within a few hours of capture. Each sample consisted of six individual fishes 8–12 cm long. Samples of single fish were obtained from commercial catches in local markets. The specimen was measured and weighed, its dorsolateral surface was scraped clean, and 10 g of epaxial white muscle tissue was removed by a clean scalpel.

Ten g of muscle tissue and 10 g of anhydrous Na_2SO_4 were concurrently homogenized and extracted twice with 75 ml petroleum ether in a Lourdes blender for 3 minutes. Each extract was decanted into an Erlenmeyer flask and left overnight for settling of fine particles and then filtered through a 3-cm-high column of anhydrous Na_2SO_4. The aliquot of extract was evaporated to dryness and the residue of extracted organic matter was weighed and recorded.

Samples were cleaned as recommended by Holden and Marsden (9). Mirex was added as an internal standard prior to concentration of the sample extract with 50–100 mg lipid residue. The sample extract was concentrated to 1 ml under vacuum by means of a rotary evaporator and applied to a 6-mm-ID column holding

2 g alumina. The alumina had been prepared by heating activated alumina (Brockmann activity I) at 500°C for 12 hours and partly deactivated by adding 5 percent distilled water by weight. Elution was performed with 15 ml hexane.

PCBs were separated from organochlorine insecticides on a miniature silica gel column according to the modified method of Snyder and Reinert (*13, 17*). Hexane eluate was evaporated to 1 ml and applied to a 10-mm column holding 100 mm silica gel. The gel was activated for 18 hours at 200°C. After cooling to room temperature, *n*-pentane was added and column was filed with a mixture of *n*-pentante and silica gel. Elution started with 32 ml *n*-pentane and was completed with 40 ml benzene. The first eluate contained PCBs and mirex; the second contained *p,p'*-DDE, *p,p'*-DDT, *p,p'*-TDE, and dieldrin.

A Hewlett-Packard 7620 model gas chromatograph (GC) equipped with ^{63}Ni electron-capture detector was used. Operating parameters for GC analysis were:

Columns:	(A) 1.8-m-by-4-mm glass packed with 1.5 percent SP-2250 + 1.95 percent SP-2401 on 100/120 mesh Supelcon AW-DMCS
	(B) 1.5-m-by-4-mm glass packed with 4 percent SE-30 + 6 percent OV-210 on 100/120 mesh Gas-Chrom Q
Temperatures:	Injector 240°C
	Column 210°C
	Detector 250°C
Carrier gas:	5 percent methane in argon
Flow rate:	30 ml/minute

Organochlorine compounds were quantitated by comparing peak areas in sample and standard chromatograms. PCBs were determined by using a standard solution of Aroclor 1254.

Experiments comparing aldrin and mirex as internal standards showed mirex to be superior. Mirex was used as an internal standard throughout the analyses because it is rather easily separated from PCBs on a GC column. Its loss was used as a measure of recovery in this study; in fact, recovery of chlorinated hydrocarbons varied between 68 and 87 percent.

For the confirmatory test samples with higher contents of DDT were hydrolyzed by KOH (*10*).

Sensitivity of DDT and its metabolites is 1 ppb wet weight and for PCBs it is 10 ppb.

In some samples low concentrations of dieldrin were found but the data are not reported in this paper.

The method of organochlorine determination was intercalibrated within the International Intercalibration Program on Chlorinated Hydrocarbons in Marine Materials funded by the United Nations Environmental Program (UNEP). Results obtained in the Centre for Marine Research were relatively close to the mean values after excluding disproportionately high residues according to criteria of Chauvenet (*5, 14*).

Results and Discussion

Concentrations of chlorinated hydrocarbons in mussels and fish from coastal waters of the eastern Adriatic are presented in Table 1. Distribution frequencies of ΣDDT and PCBs in mussel and fish samples are presented in Figure 2. The level of organochlorine concentrations varied widely, which is not unreasonable considering the unusual pollution pattern and hydrography of the Adriatic Sea and the complexity of the biotic samples analyzed.

Figures 3 and 4 present arithmetic means and ranges of DDT and its metabolites, dieldrin, and PCBs in mussels, goby fishes, and several species of benthic fishes. Although 14 species of benthic fishes were analyzed in the present investigation, results are presented only for those species which had three or more valid samples analyzed. Except for gobies, fish species are presented by decreasing order of summed pesticide and PCB concentrations. Comparing these two decreasing orders shows that the position of fish species differs according to whether the concentrations of pollutants are presented as wet weight or as extracted organic matter. But both figures indicate that fish species living in similar environments and eating similar food have similar concentrations of pollutants.

Most specimens of goby fishes were caught in highly polluted coastal waters, especially semiclosed harbors polluted with industrial and domestic wastes, but concentrations of chlorinated hydrocarbons in these fishes are not significantly higher than in other commercial fishes such as mullet, annular gilthead, and black tail sea bream. However, these differences become significant when concentrations of pollutants are compared as extracted organic matter (Figure 4).

Stations for monitoring chlorinated hydrocarbon pollution of eastern coastal waters of the north and the middle Adriatic Sea are located in four different areas. The Istrian coastal area belongs to the northern region of the Adriatic Sea; Rijeka, Zadar, and Losinj areas belong to the so-called Region of Islands (*18*). The northern region of the Adriatic is predominantly affected by river waters from northern Italy which create the most severe pollution problem in the whole Adriatic. Intensive urban, tourist, agricultural, and industrial development in both coastal areas contributes to the problem. The Region of Islands includes water surrounding nearly 1000 islands along the eastern Adriatic coast and semiseparated waters between islands and main-

TABLE 1. *Chlorinated hydrocarbon concentrations in fish and mussels of east coastal waters of middle and north Adriatic Sea, 1974–75*

Station No.	Species[1]	Sampling Date	*p,p'*-DDT EOM, %	*p,p'*-DDT wet weight	*p,p'*-DDT EOM, ppm	*p,p'*-DDE wet weight	*p,p'*-DDE EOM, ppm	*p,p'*-TDE wet weight	*p,p'*-TDE EOM, ppm	Dieldrin wet weight	Dieldrin EOM, ppm	PCBs wet weight	PCBs EOM, ppm
						ISTRIAN COAST							
1	M.G.	March 1974	1.63	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1	M.G.	March 1974	1.25	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	M.G.	March 1974	2.79	ND	ND	8	1.40	ND	ND	—	—	ND	ND
2	M.G.	Sept. 1974	0.71	29	4.10	21	3.00	26	3.60	ND	ND	85	11.97
2	M.G.	Sept. 1974	0.37	13	3.50	13	3.40	14	3.80	1	0.32	34	9.20
2	M.G.	March 1974	2.94	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	G.	Sept. 1974	0.84	16	1.90	15	1.80	13	1.60	2	0.24	ND	ND
3	M.G.	March 1974	1.16	23	1.94	18	1.51	10	1.81	3	0.26	ND	ND
3	M.G.	March 1974	2.53	41	1.65	15	0.60	13	0.53	—	—	25	0.98
3	M.G.	March 1974	8.03	45	0.56	39	0.48	17	0.21	—	—	115	1.43
3	M.G.	Sept. 1974	0.62	15	2.41	19	3.05	20	3.22	4	0.58	ND	ND
3	M.G.	Sept. 1974	0.62	34	5.48	29	4.68	38	6.13	9	1.45	168	27.10
3	M.G.	Sept. 1974	1.37	27	1.93	49	3.28	28	2.12	4	0.26	85	6.20
4	M.G.	Oct. 1972	3.79	105	2.78	30	0.80	53	1.40	—	—	367	9.68
4	M.G.	March 1973	1.52	35	2.30	65	4.30	44	2.90	—	—	256	16.80
5	M.G.	Oct. 1972	2.26	ND	ND	1	0.06	ND	ND	—	—	4	0.16
5	M.G.	March 1973	1.22	ND	ND	ND	ND	ND	ND	—	—	ND	ND
5	M.G.	Oct. 1975	0.41	2	0.44	1	0.16	1	0.16	ND	ND	ND	ND
	D.A.	Sept. 1974	4.05	130	3.21	80	1.98	40	0.99	13	0.31	195	4.80
	O.M.	Sept. 1974	1.30	46	3.53	27	2.07	29	2.22	4	0.34	45	3.50
	B.B.	Sept. 1974	2.75	133	4.85	43	1.87	30	1.09	—	—	422	15.36
	P.E.	Sept. 1974	0.91	9	0.99	14	1.54	5	0.48	1	0.12	45	4.90
	M.A.	Oct. 1973	1.57	24	1.5	29	1.84	15	0.95	ND	ND	ND	ND
	O.M.	Sept. 1974	2.76	60	2.17	36	1.30	18	0.65	4	0.15	80	2.90
	P.E.	Sept. 1974	2.59	4	0.15	16	0.62	13	0.50	2	0.08	ND	ND
	M.B.	Sept. 1974	2.64	30	1.13	20	0.76	14	0.53	6	0.24	ND	ND
	M.A.	Sept. 1974	3.67	64	1.95	48	1.31	76	2.07	15	0.40	520	14.20
						RIJEKA AREA							
1	M.G.	March 1974	0.52	ND	ND	ND	ND	ND	ND	—	—	ND	ND
1	M.G.	March 1974	0.80	15	1.85	7	0.87	ND	ND	—	—	8	0.94
1	M.G.	Sept. 1974	0.68	5	0.74	4	0.53	4	0.53	ND	ND	11	1.60
1	M.G.	Sept. 1974	1.25	12	0.96	5	0.40	13	1.02	ND	ND	192	14.20
1	G.	Sept. 1974	0.89	8	0.84	9	0.96	3	0.35	1	0.07	27	3.10
2	M.G.	March 1974	2.20	131	6.05	49	2.22	32	1.45	ND	ND	23	1.03
2	M.G.	March 1974	0.74	7	1.25	5	0.65	10	1.28	0.3	0.09	ND	ND
2	M.G.	March 1974	1.20	83	6.90	21	1.77	10	0.79	ND	ND	75	6.20
2	M.G.	March 1974	1.05	28	2.52	9	0.90	7	0.65	ND	ND	8	0.84
2	M.G.	March 1974	1.35	15	1.10	8	0.61	7	0.54	—	—	9	0.65
2	M.G.	March 1974	1.20	63	5.20	28	2.30	38	3.15	—	—	128	9.80
2	M.G.	Sept. 1974	0.74	8	1.02	4	0.47	12	1.57	ND	ND	168	22.50
2	M.G.	Sept. 1974	0.82	7	0.85	2	0.25	8	1.02	ND	ND	75	9.10
2	M.G.	Sept. 1974	0.63	23	3.65	4	0.55	22	3.42	ND	ND	83	13.20
2	M.G.	Sept. 1974	0.56	42	7.50	5	0.80	48	8.60	ND	ND	77	13.70
2	M.G.	Sept. 1974	0.58	22	3.80	8	1.29	36	6.20	ND	ND	164	28.20
3	M.G.	March 1974	1.70	23	1.32	5	0.28	11	0.64	3	0.18	63	3.70
3	M.G.	Sept. 1974	0.56	13	2.20	6	1.03	9	1.60	2	0.29	64	11.40
3	G.	Sept. 1974	1.06	8	0.72	5	0.43	9	0.85	1	0.12	168	15.90
4	M.G.	March 1973	1.10	49	4.50	17	1.54	6	0.52	—	—	234	21.40
4	M.G.	Oct. 1975	0.24	2	0.79	1	0.42	1	0.59	ND	ND	26	10.60
5	G.	Oct. 1975	3.29	49	1.48	86	2.60	14	0.44	ND	ND	159	4.90
	D.A.	Sept. 1974	2.03	4	0.17	2	0.10	2	0.10	1	0.05	16	0.76
	M.A.	Oct. 1975	4.15	35	0.85	32	0.78	28	0.67	8	0.20	356	8.60
	B.B.	Oct. 1975	14.13	30	0.21	29	0.20	10	0.07	10	0.07	174	1.20
	M.B.	Sept. 1974	1.95	ND	ND	9	0.46	10	0.52	ND	ND	115	5.85
	P.E.	Sept. 1974	0.53	4	0.72	6	1.10	1	0.15	—	—	4	0.71
	M.Mer.	Sept. 1974	0.32	14	4.40	14	4.40	2	0.77	—	—	8	2.35
	M.Mer.	Oct. 1975	1.75	20	1.11	8	0.47	8	0.47	ND	ND	98	5.57
	G.M.	Oct. 1975	0.92	ND	ND	ND	ND	ND	ND	ND	ND	25	2.70
	M.B.	Oct. 1975	2.52	ND	ND	ND	ND	ND	ND	ND	ND	53	2.08
	P.D.	Sept. 1974	1.20	11	0.92	22	1.84	5	0.35	2	0.13	28	2.30
	L.C.	Sept. 1974	0.66	12	1.82	19	2.80	7	1.14	2	0.24	20	3.00
						ZADAR AREA							
1	M.G.	March 1974	3.20	14	0.42	9	0.28	ND	ND	—	—	ND	ND
1	M.G.	March 1974	2.60	17	0.64	9	0.33	ND	ND	—	—	ND	ND
1	M.G.	Sept. 1974	0.93	13	0.13	1	0.07	19	2.04	1	0.07	ND	ND
1	M.G.	Sept. 1974	0.87	33	3.80	3	0.32	ND	ND	2	0.26	80	9.20
1	G.	March 1974	1.69	ND	ND	ND	ND	ND	ND	—	—	ND	ND
1	G.	Sept. 1974	1.17	8	0.68	6	0.51	7	0.60	2	0.14	ND	ND
2	M.G.	March 1974	1.10	7	0.59	7	0.59	ND	ND	—	—	ND	ND
2	M.G.	March 1974	1.40	11	0.81	4	0.28	6	0.43	ND	ND	ND	ND
2	M.G.	March 1974	1.70	63	3.70	28	1.62	11	0.62	—	—	200	11.60
2	M.G.	March 1974	1.76	37	2.25	14	0.78	23	1.32	ND	ND	345	19.50
2	M.G.	March 1974	1.07	33	3.10	10	0.97	20	1.87	4	0.37	390	36.50

(*Continued next page*)

TABLE 1 (cont'd.). *Chlorinated hydrocarbon concentrations in fish and mussels of east coastal waters of middle and north Adriatic Sea, 1974–75*

Station No.	Species[1]	Sampling Date	p,p'-DDT EOM, %	p,p'-DDT wet weight	p,p'-DDT EOM, ppm	p,p'-DDE wet weight	p,p'-DDE EOM, ppm	p,p'-TDE wet weight	p,p'-TDE EOM, ppm	Dieldrin wet weight	Dieldrin EOM, ppm	PCBs wet weight	PCBs EOM, ppm
2	M.G.	Sept. 1974	0.49	5	1.02	2	0.45	3	0.65	ND	ND	11	2.30
2	M.G.	Sept. 1974	0.72	6	0.76	4	0.50	5	0.69	ND	ND	36	5.00
2	M.G.	Sept. 1974	0.71	18	2.55	18	2.55	24	3.38	1	0.20	326	46.00
2	M.G.	Sept. 1974	1.66	7	0.42	6	0.34	14	0.80	1	0.07	336	22.20
2	M.G.	Sept. 1974	0.76	6	0.79	7	0.92	7	0.92	ND	ND	36	4.80
2	G.	March 1974	0.70	43	6.07	113	16.07	68	9.64	2	0.29	148	21.10
2	G.	Sept. 1974	1.60	17	1.06	14	0.85	2	0.10	3	0.16	11	0.68
						LOSINJ ISLAND							
1	M.G.	March 1974	1.58	375	23.80	88	5.50	134	8.50	—	—	200	12.70
1	M.G.	March 1974	1.60	46	2.90	25	1.56	44	2.70	7	0.43	138	8.60
1	M.G.	March 1974	1.60	138	8.60	61	3.85	75	4.70	—	—	ND	ND
1	M.G.	Sept. 1974	0.78	8	0.98	5	0.50	8	0.98	ND	ND	120	15.40
1	M.G.	Sept. 1974	0.73	25	3.42	7	0.95	46	6.30	ND	ND	222	30.40
1	M.G.	Sept. 1974	0.57	8	1.32	5	0.79	22	3.80	ND	ND	157	27.50
1	M.G.	Oct. 1975	0.84	33	3.86	16	1.88	33	3.86	ND	ND	94	11.20
1	G.	March 1974	1.41	90	6.40	45	3.20	98	6.91	ND	ND	ND	ND
1	G.	March 1974	1.30	78	6.00	30	2.30	83	6.40	4	0.31	43	3.30
1	G.	Sept. 1974	0.73	44	6.04	68	9.32	870	119.00	3	0.40	152	20.80
2	M.G.	March 1974	1.40	119	8.50	44	3.13	38	2.73	—	—	ND	ND
2	M.G.	March 1974	2.20	128	5.80	39	1.76	41	1.85	—	—	112	5.40
2	M.G.	Sept. 1974	1.13	27	2.38	27	2.38	159	14.10	ND	ND	130	11.30
2	M.G.	Sept. 1974	1.20	13	1.08	9	0.71	78	6.50	ND	ND	202	16.90
2	M.G.	Oct. 1975	0.52	30	5.80	24	4.62	27	5.20	ND	ND	220	42.30
2	G.	March 1974	1.60	94	5.61	20	1.20	19	1.13	—	—	724	45.10
2	G.	Sept. 1974	1.48	17	1.15	59	3.95	250	17.00	ND	ND	112	7.60
	M.A.	Oct. 1975	9.41	172	1.83	107	1.14	130	1.38	ND	ND	295	3.12
	D.A.	Sept. 1974	15.40	215	1.39	158	1.03	120	0.78	13	0.08	360	2.34
	D.A.	Oct. 1975	1.57	7	0.44	3	0.18	1	0.07	1	0.07	14	0.86
	O.M.	Sept. 1974	3.11	82	3.65	70	2.25	50	1.60	7	0.22	624	20.00
	O.M.	Oct. 1975	1.65	25	1.50	15	0.91	10	0.61	ND	ND	90	5.50
	B.B.	Sept. 1974	2.00	43	2.12	38	1.87	14	0.69	—	—	151	7.50
	M.B.	Oct. 1975	8.61	42	0.49	85	0.99	37	0.43	5	0.06	128	1.50
	P.E.	Oct. 1975	0.60	17	0.88	16	2.63	6	1.00	ND	ND	54	9.00
	B.S.	Sept. 1974	1.68	8	0.65	7	0.39	8	0.45	5	0.27	ND	ND
	B.S.	Oct. 1975	2.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	S.S.	Oct. 1975	3.78	15	0.36	21	0.50	ND	ND	4	0.10	102	2.40
	M.Ma.	Oct. 1975	1.31	90	6.90	62	4.75	30	2.30	2	0.13	40	3.05

Note: ND = not detectable; — = not measured; EOM = extracted organic matter.

[1] Names of species in Latin, English, and Croatoserbian: M.G. = *Mytilus galloprovincialis*, Mediterranean mussel, Dagnja; G. = *Gobius* (several species), Goby, Glavoc; D.A. = *Diplodus annularis* L., Annular gilthead, Spar; O.M. = *Oblada melanura* L., Saddled bream, Usata; B.B. = *Boops boops* L., Bogue, Bukva; P.E. = *Pagellus erythrinus* L., Pandora, Rumenac; M.A. = *Mugil auratus risso*, Golden grey mullet, Skocac zlatac; M.B. = *Mullus barbatus*, Red mullet, Barbun; M.Mer. = *Merlucius merlucius* L., Hake, Oslic; G.M. = *Gadus merlangus* L., Whiting, Mol; L.C. = *Lepidotrigla cavilone* Lac., unknown, Cucin; B.S. = *Boops salpa* L., Saupe, Salpa; S.S. = *Serranus scriba* L., Painted comber, Pirka; M.Ma. = *Maena maena* L., Caockarel, Modrak; T.D. = *Trachinus draco* L., Greater weever, Pauk bijelac.

land. Sparsely populated karstic islands and mountains, with modest agriculture and almost no industry, constitute the hinterland of these waters. But also in this region are several pollution nuclei: the Bay of Rijeka and nearby towns of Bakar, Zadar, and Sibenik; the Bay of Kastela and the neighboring town of Split.

Chlorinated hydrocarbon pollutants of marine environments can originate from such land-based sources as direct industrial discharges, sewage, and rubbish. But indirect discharges of these pollutants, especially as agricultural runoff of pesticides and farm wastes into rivers, also contribute significantly to their concentration in marine environments (*4, 7, 16*). These direct and indirect discharges are the most common sources of local pollution. Air is an important secondary source of chlorinated hydrocarbon pollution (*1*); wet and dry fallout contributes to the regional or even global pollution of the marine environment.

Concentrations of ΣDDT, dieldrin, and PCBs in mussels, goby fishes, and other benthic fishes according to their sampling areas are presented in Figures 5–7. Stationary species of mussels and goby fishes, which are indicators of local pollution, were often sampled near the source of waste discharges. Other benthic fishes indicate broader areas of pollution. Data in the figures show differences in arithmetic means of residues in mussels, goby fishes, and benthic fishes between the areas investigated. Since concentrations vary considerably, ΣDDT and PCB residues in mussels and benthic fishes were analyzed in order to find whether arithmetic means differ significantly among the areas investigated (Table 2). Mussels from the Losinj area had significantly higher concentrations of ΣDDT than had those from any other area investigated. Significantly higher PCB concentrations were found in the Losinj area than along the Istrian coast and Bay of Rijeka, but PCB residues were lower than were DDT concentrations. In fish

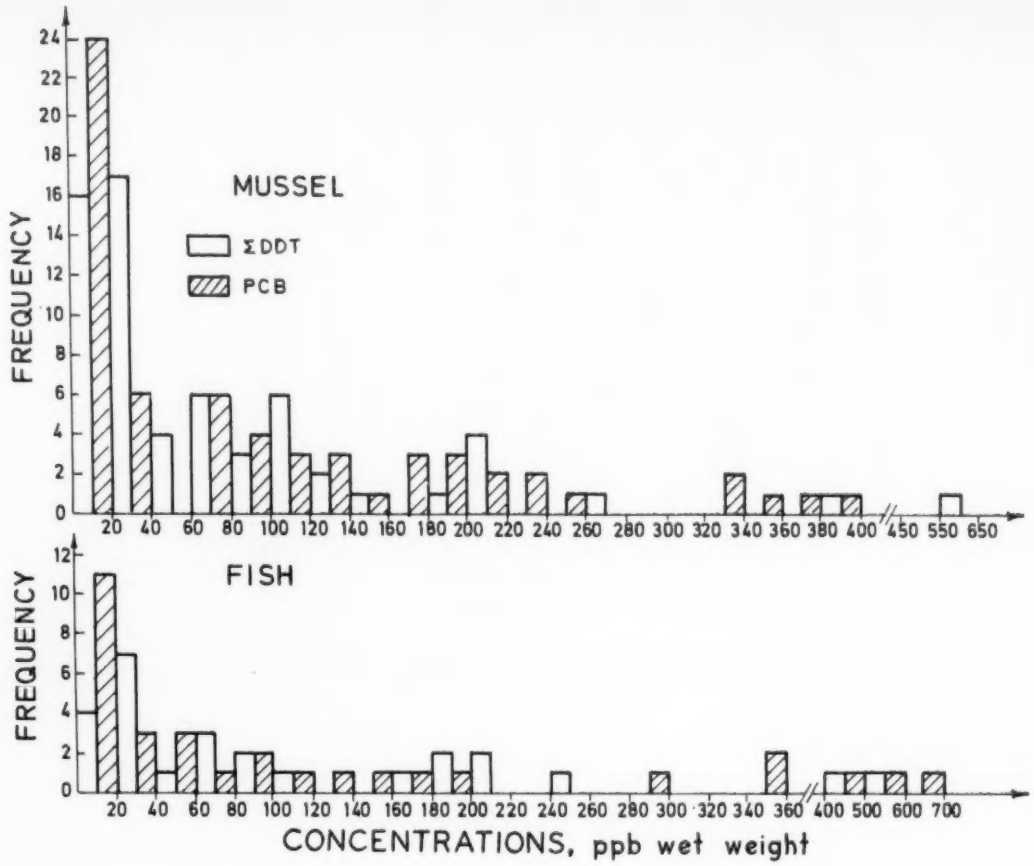

FIGURE 2. *Distribution frequencies of ΣDDT and PCBs in mussels and fish from east coastal waters of middle and north Adriatic Sea*

samples, the only concentrations that differed significantly by area were ΣDDT concentrations in samples from Rijeka Bay versus those from the Losinj area and in samples from the Istrian coast versus those from the Rijeka area. PCB concentrations did not differ significantly.

Table 3 shows significant differences in arithmetic means of ΣDDT and PCB concentrations in fish and mussel samples from the same area. No major difference between ΣDDT and PCB concentrations is indicated in mussels and benthic fishes from the same area. Significant difference appears only in ΣDDT concentrations in fish from the Istrian coastal area.

The ratio of PCB and pesticide concentrations frequently is used for identifying chlorinated hydrocarbon pollution of marine areas. If this ratio is higher than 1, the source of pollution is more likely industrial than agricultural. The ratios of PCB and ΣDDT concentrations in samples investigated during the present monitoring program are given in Figure 8. Only in the Rijeka area is this ratio significantly higher than 1 for all the indicator organisms investigated.

To determine main sources of chlorinated hydrocarbon pollution in eastern Adriatic coastal waters, correlation between ΣDDT and PCB concentrations in mussel and fish samples was investigated (Figure 9). Statistical results of the analysis are presented in Table 4 as Pearson's correlation coefficients.

Significant correlation between concentrations of ΣDDT and PCBs existed only in mussels from the Istrian coastal area and fish from the Rijeka area. This suggests two possibilities: different sources of DDT and PCB residues in the areas investigated, or different uptake and loss pathways of ΣDDT and PCBs for mussels and fish.

Several papers have been published on investigations of chlorinated hydrocarbons in Adriatic biota and sedi-

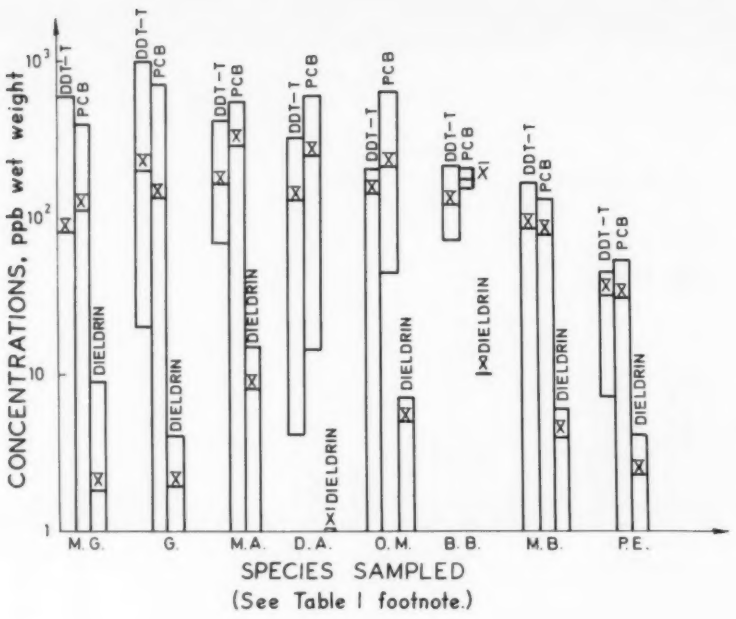

FIGURE 3. *Concentrations (wet weight) of ΣDDT, dieldrin, and PCBs in mussels and fish from east coastal waters of middle and north Adriatic Sea*

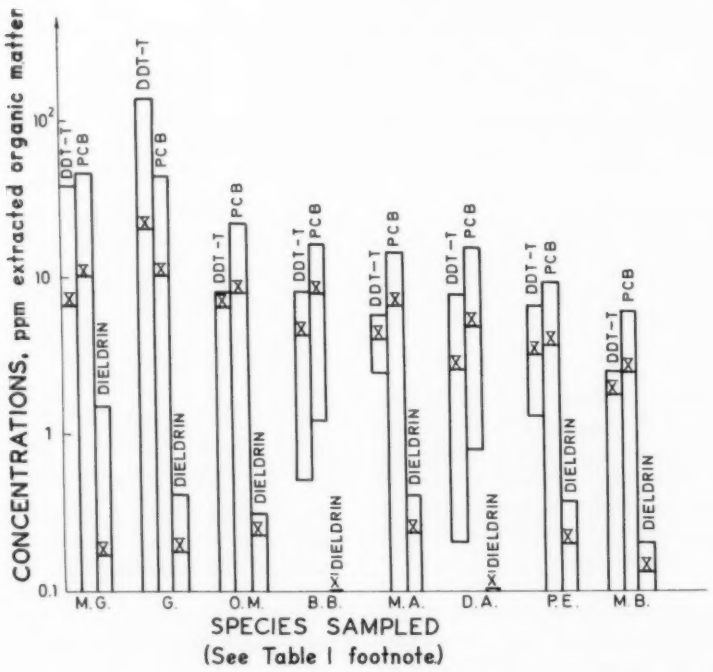

FIGURE 4. *Concentrations (extracted organic matter) of ΣDDT, dieldrin, and PCBs in mussels and fish from east coastal waters of middle and north Adriatic Sea*

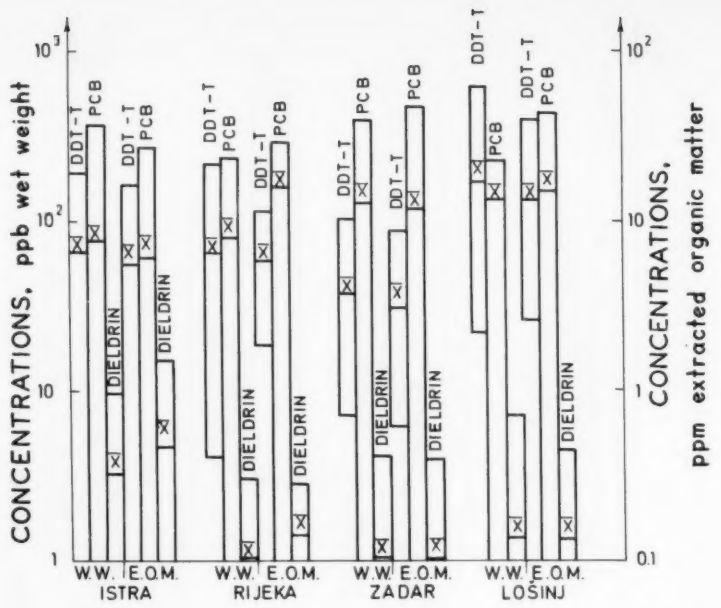

FIGURE 5. *Comparison of ΣDDT, dieldrin, and PCB concentrations in mussels from east coastal waters of middle and north Adriatic Sea*

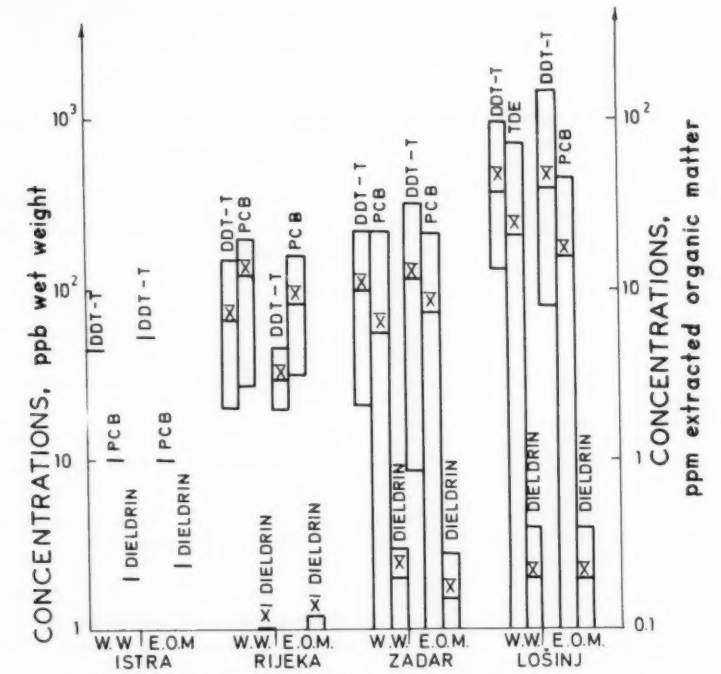

FIGURE 6. *Comparison of ΣDDT, dieldrin, and PCB concentrations in goby fishes from east coastal waters of middle and north Adriatic Sea*

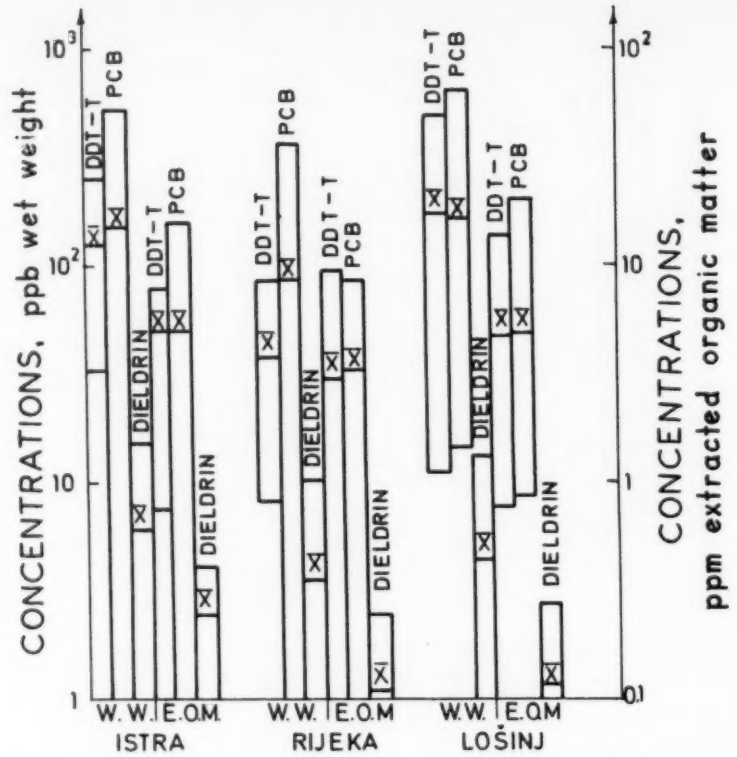

FIGURE 7. *Comparison of ΣDDT, dieldrin, and PCB concentrations in benthic fishes from east coastal waters of middle and north Adriatic Sea*

TABLE 2. *Results of Student's t-test for ΣDDT and PCB concentrations in mussels and fish from same areas of middle and north Adriatic Sea, 1974–75*

	Significant Difference of Arithmetic Means			
	ΣDDT		PCBs	
Compared Areas	Mussels	Fishes	Mussels	Fishes
Istrian coast—Rijeka	None	0.01	None	None
Istrian coast—Zadar	0.1	NC	None	NC
Istrian coast—Losinj Island	0.1	None	0.1	None
Rijeka—Zadar	0.1	NC	0.1	NC
Rijeka—Losinj Island	0.01	0.05	0.1	None
Zadar—Losinj Island	0.01	NC	None	NC

Note: NC=not calculated.

TABLE 3. *Results of Student's t-test for ΣDDT and PCB concentrations in mussels and fish from same areas of middle and north Adriatic Sea, 1974–75*

	Significant Difference of Arithmetic Means	
Area	ΣDDT	PCBs
Istrian coast	0.05	None
Rijeka	None	None
Losinj Island	None	None

ments (*3, 15, 18, 20, 21*). But difficulties of analyzing chlorinated hydrocarbons in marine samples are numerous (*5, 14*), and results of the present study were not compared with published results because analytical methods of the various studies have not been intercalibrated.

Conclusions

Analyses of chlorinated hydrocarbons in biota from eastern coastal waters of the middle and north Adriatic sea lead authors to several conclusions.

Although major north Italian rivers polluted with chlorinated hydrocarbons discharge their loads into the North Adriatic, samples from Istrian coastal waters did not have significantly higher concentrations of these pollutants than did other waters.

High concentrations of chlorinated hydrocarbons in marine organisms from Losinj Island indicate a probable uptake of pollutants in North Adriatic waters.

Chlorinated hydrocarbon levels often differ dramatically in samples collected at stations which are close together,

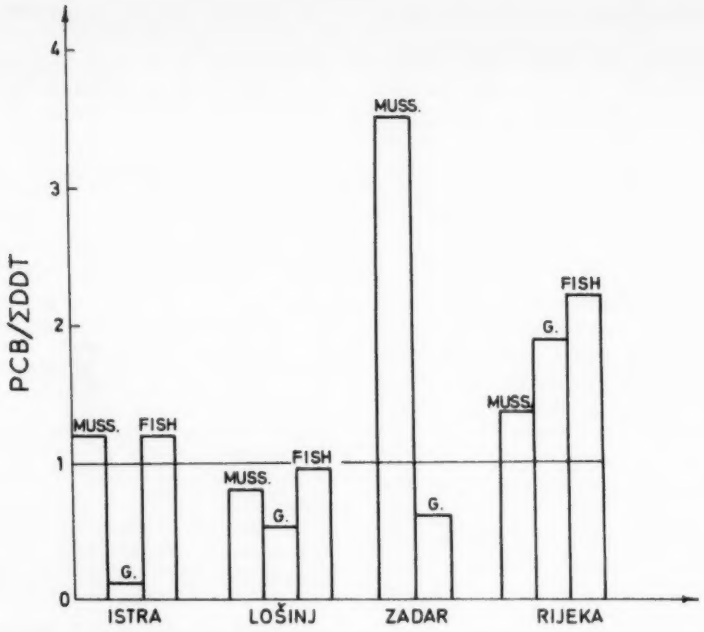

FIGURE 8. *Comparison of ratios of PCBs to ΣDDT concentrations in mussels, goby fishes, and benthic fishes from east coastal waters of middle and north Adriatic Sea*

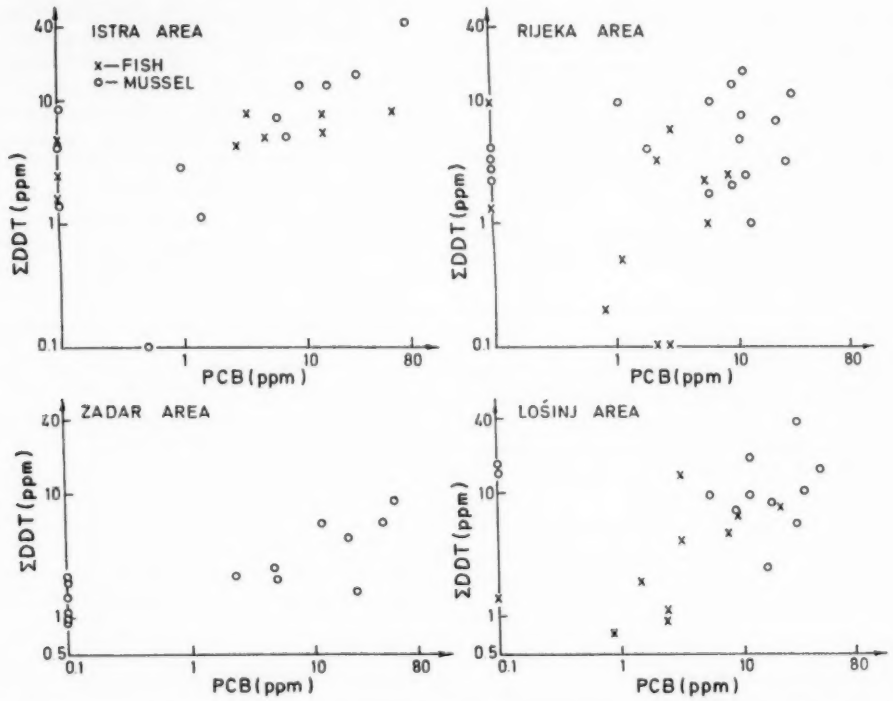

FIGURE 9. *Correlation of ΣDDT and PCB concentrations in mussels and benthic fishes from east coastal waters of middle and north Adriatic Sea*

TABLE 4. *Pearson's coefficient of correlation between ΣDDT and PCB concentrations in mussels and fish from coastal waters of middle and north Adriatic Sea, 1974–75*

AREA	MUSSELS	FISH
Istrian coast	0.927	0.740
Rijeka	0.205	0.815
Zadar	0.712	NC
Losinj Island	−0.069	0.578

Note: NC=not calculated.

possibly because the first station waters had been contaminated with waste waters and the second station had not. Evidently urban waste waters even from small settlements contribute significantly to the contamination of Adriatic coastal waters by chlorinated hydrocarbon pollutants.

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Organochlorine Residues and Reproduction in the Little Brown Bat, Laurel, Maryland—June 1976

Donald R. Clark, Jr., and Alex Krynitsky[1]

ABSTRACT

Twelve of 43 pregnant little brown bats (Myotis lucifugus) *collected at Montpelier Barn, Laurel, Maryland, gave birth to dead young. Eleven of these 12 dead neonates were abnormally small. Most of the stillbirths were attributable to unknown reproductive difficulties associated with first pregnancies, but four may have been due to high concentrations of polychlorinated biphenyls (PCB) in the newborn. Residues of the PCB, DDE, and oxychlordane crossed the placenta at similar rates.*

Introduction

A study of wild-caught, pregnant big brown bats *(Eptesicus fuscus)* suggested that Aroclor 1260, a polychlorinated biphenyl (PCB), caused young to be stillborn (*3*). However, experimental elevation of Aroclor 1260 levels produced no additional stillbirths (*2*). The results indicated only that both stillbirths and high levels of Aroclor 1260 were characteristic of young adult female big brown bats.

The present study was undertaken after dead neonate little brown bats *(Myotis lucifugus)* were observed at Laurel, Maryland, roosts. Authors wished to determine whether high organochlorine residues are associated with stillbirths of little brown bats and, if so, whether this association resembles that found in big brown bats.

Materials and Methods

On June 3, 1976, 45 pregnant little brown bats were collected in Montpelier Barn at the Montpelier Mansion State Historical Site, Laurel, Prince Georges County, Maryland. Bats were confined individually at Patuxent Wildlife Research Center in stainless steel wire mesh cages, 18 cm × 22 cm × 37 cm, equipped with rodent watering bottles. Laboratory temperature averaged 28.2°C. Subdued sunlight entered two draped windows.

Before being caged, the bats were anesthetized individually with the inhalant anesthetic Metofane (Pittman-Moore, Inc., Fort Washington, Pennsylvania) and the occlusal tip width of the upper canine (canine tip width, CTW) was measured with an ocular micrometer in a 30× dissecting microscope. This measurement is an indicator of relative age (*1*).

Pregnant bats were fed mealworms, larvae of the beetle *Tenebrio molitor*, samples of which had been found free of organochlorine residues.

Parturition began June 3, and the last young was born June 13. All pregnancies produced single young. After parturition, each female and her young were killed by freezing. Two females never gave birth: one died of unknown causes June 8, and the other was frozen June 8 because she apparently was not pregnant although a small embryo (0.564 g) was found during dissection.

ANALYTICAL PROCEDURES

Adults were prepared for analysis as carcasses; young were analyzed whole, except for removal of the gastrointestinal tract, according to procedures described previously (*2*). Gastrointestinal tracts were left in several small fetuses (0.9 g or less) where removal would have been difficult.

Samples were ground with anhydrous sodium sulfate. The dried mixture was extracted with hexane in a paper extraction thimble on a Soxhlet extractor for about 7 hours. The extract was cleaned by Florisil column chromatography, and the eluate containing the pesticides and PCB was fractionated by Silicar column chromatography (*5*). The fractions were analyzed with a Hewlett-Packard Model 5753 gas-liquid chromatograph equipped with a ^{63}Ni detector, automatic sampler, and computing integrator. Instrument parameters and operating conditions follow:

Column:	glass, 1.83 m, packed with a mixture of 1.5 percent OV-17 and 1.95 percent QF-1
Temperatures:	column 200°C, detector 300°C, injection port 250°C
Carrier gas:	5 percent methane in argon flowing at 60 ml/minute; purge flow, 40 ml/minute

[1] Fish and Wildlife Service, U.S. Department of the Interior, Patuxent Wildlife Research Center, Laurel, MD 20811.

Samples were analyzed for *p,p'*-DDE, *p,p'*-TDE, *p,p'*-DDT, dieldrin, endrin, heptachlor epoxide, mirex, oxychlordane, *cis*-chlordane, *trans*-nonachlor, *cis*-nonachlor, hexachlorobenzene (HCB), toxaphene, and PCBs. The PCB that was recovered resembled Aroclor 1260 in all cases.

Recoveries from spiked mallard duck *(Anas platyrhynchos)* tissues ranged from 80 to 104 percent. Residue data were not adjusted on the basis of these recoveries. The lower limit of sensitivity was 0.1 ppm. Residues in 10 percent of the samples were confirmed on an LKB Model 9000 gas-liquid chromatograph–mass spectrometer operated as described previously (*5*). Samples for one adult and two young were lost during analysis. Results are given as ppm wet weight.

Geometric means are given for residues because the data were positively skewed. Arithmetic means are given with standard errors; geometric means are given with 95 percent confidence intervals (CI). Residue levels reported as not detected (ND) were entered as zeros. To allow conversion to logs and/or machine plotting of the data, a constant was added to each value in those data series that included zeros (Fig. 1). Regression lines were fitted by the least-squares method.

Results and Discussion

CONDITION OF NEWBORN LITTLE BROWN BATS

Of 43 bats that gave birth, 12 (27.9 percent) produced dead young. Eleven of the 12 dead young weighed less (0.048–0.869 g) than the smallest liveborn bat (1.072 g). The twelfth dead neonate weighed 1.541 g. Six of the 12 dead young were partly eaten by their mothers: one young was missing its wing tips; a second, one wing and one foot; and a third, both wings and both feet. Only the head and the vertebral column of the fourth remained, and only heads remained of the other two.

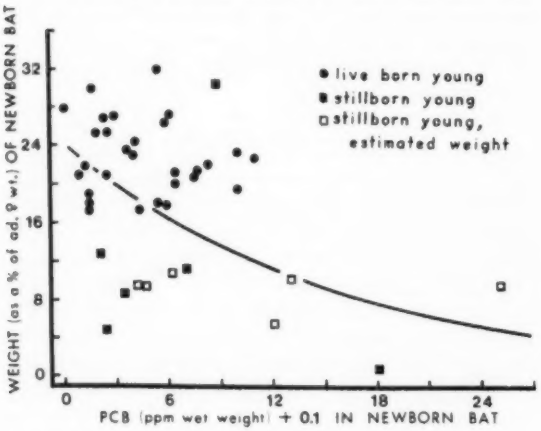

FIGURE 1. *Relationship of weight as a percent of adult female weight to Aroclor 1260 concentration among 41 neonatal little brown bats*
(Sample includes all neonates except two whose extracts were lost during chemical analysis.)

Total weights of the six young were estimated from the remaining portions. Estimations for the latter three young were based on a head-length-to-body-weight relationship derived from the undersized dead young that were recovered intact. The incompleteness of these six specimens probably did not seriously bias the results of the chemical analyses except perhaps for the latter three, which may actually have contained higher concentrations of chemicals than were estimated because most of the young bats' fat, and, therefore, residues, was in the body portions eaten by the mother. Nevertheless, residues of the PCB for these three bats (6.1, 12, and 25 ppm) exceeded the mean (Table 1) and included the maximum.

Wimsatt (*6*) observed several times that a majority of a group of females of *Myotis lucifugus* in advanced pregnancy aborted their fetuses, usually stillborn, within a few hours of removal from a colony. He attributed this result to handling or confinement. In the present study, dead young tended to be more common among later births, but beyond this tendency there was no clear pattern. When all 43 births were divided into four groups of 11, 11, 11, and 10 according to chronological order, the incidences of dead young were 9.1, 18.2, 54.5, and 30.0 percent, respectively. So, the possible roles of handling and confinement in stillbirths were not clarified by the present study.

TABLE 1. *Principal organochlorine residues in adult female little brown bats and their young, Laurel, Maryland—June 1976*

Chemical	Residues, ppm Wet Weight	
	Adults ($n = 44$)	Young ($n = 43$)
PCB (Aroclor 1260)		
Geometric mean	11.38	4.16[1]
95% CI	9.68–13.38	3.08–5.61
Range	3.6–24	ND–25
DDE		
Geometric mean	1.65	0.50[2]
95% CI	1.50–1.82	0.36–0.69
Range	0.72–3.4	ND–2.2
DDT		
Geometric mean	0.08[3]	—[4]
95% CI	0.05–0.13	—
Range	ND–1.0	—
Oxychlordane		
Geometric mean	0.45[2]	—[4]
95% CI	0.33–0.60	—
Range	ND–1.6	—
Dieldrin		
Geometric mean	0.13[5]	—[4]
95% CI	0.08–0.19	—
Range	ND–0.94	—

NOTE: CI = confidence interval; ND = not detected.
[1] Residue was not detected in 1 sample.
[2] Residue was not detected in 2 samples.
[3] Residue was not detected in 12 samples.
[4] Residue was not detected in 20 or more samples.
[5] Residue was not detected in 7 samples.

GENERAL LEVELS OF RESIDUES

Except for the PCB, levels of organochlorines in females and their young were generally low (Table 1) and similar to those found in big brown bats from Montpelier Barn (*3*). Levels of the PCB in adult little brown bats were 5.8 times greater than those found in the June 1974 collections of big brown bats; the amounts in newborn little brown bats were 3.5 times greater than those in newborn big brown bats (*3*).

Eighteen pregnant big brown bats that had been dosed with Aroclor 1260 (*2*) contained 1.8 times the concentration found in little brown bats in the present study when their carcasses were analyzed after parturition. The young of big brown bats contained a mean residue of 4.38 ppm, similar to the mean residue of 4.16 ppm found in neonates in the present study.

PLACENTAL TRANSFER OF RESIDUES

Amounts in micrograms of the PCB, DDE, and oxychlordane in young were computed as percentages of the amounts in adults, using the 29 females whose live-born young appeared to be full-term. The results were 13.2 ± 1.3 percent, 14.3 ± 1.5 percent, and 8.6 ± 1.7 percent, respectively. Paired t tests showed that the average percentage for oxychlordane was significantly less than that of either of the other chemicals. However, 13 of the values for oxychlordane in newborns were zero (not detected), and when zero values were eliminated ($n = 16$) the respective averages became 15.6 ± 1.9 percent, 17.0 ± 2.2 percent, and 15.5 ± 1.6 percent and there were no significant differences. Elimination of zeros was probably justified for this comparison because the small absolute amounts of oxychlordane made their detection less likely. These percentages resembled those for both control and dosed big brown bats when Aroclor 1260 was fed experimentally (*2*), but they were lower than one of two percentages for Aroclor 1260 and higher than both percentages for DDE found earlier in big brown bats that had not been dosed (*3*).

RESIDUES AND DEAD YOUNG

Dead young averaged more than twice as much PCB (mean = 6.68 ppm, $n = 12$) as did live young (mean = 3.04 ppm, $n = 29$), but the difference was not significant at the 95 percent level ($t = 1.91$, $0.1 > p > 0.05$). Levels of DDE and oxychlordane were almost identical in dead and live young.

Possible effects of the PCB on weight of the young were calculated by correlating the ppm PCB in the young with the weight of the young expressed as a percentage of adult female weight; the result (Fig. 1) was significant ($r = -0.47$, $0.01 > p > 0.001$). When the six data points based on estimated weights were eliminated, the relationship remained significant ($r = -0.46$, $0.01 > p > 0.001$). Although this relationship suggests that the PCB may have caused some neonates to be small, the plotted data in Figure 1 also indicate that neonates may at the same time be small and contain little PCB. A similar analysis for DDE produced no significant correlations.

To determine whether weight of the young was related to residues in adult females, a correlation was made between weight of the young as a percentage of adult female weight, and ppm of the PCB, DDE, DDT, oxychlordane, and dieldrin in adult females. No significant relationships were found. Also, females that produced dead young did not contain residues significantly higher than those of females that produced live young.

RESIDUES IN FEMALES COMPARED WITH RESIDUES IN YOUNG

The relationships between total micrograms of the PCB, DDE, and oxychlordane in adult females and in their newborn young were tested using all 29 pairs of females and young in which the neonates were entire and of normal size. Micrograms of residues in the young were dependent in a positive, linear fashion on the amount in the adult female: PCB $r = 0.74$, $p < 0.001$; DDE $r = 0.60$, $p < 0.001$; oxychlordane $r = 0.48$, $0.01 > p > 0.001$. Similar relationships were found in other bat species (*3, 4*).

RESIDUES COMPARED WITH DAYS IN CAPTIVITY

Micrograms of residues of the PCB, DDE, DDT, oxychlordane, dieldrin, and *trans*-nonachlor in carcasses of adult females were compared to days in captivity for all 44 females in which residues were measured. Only oxychlordane declined significantly, from an average 2.6 μg to 1.0 μg. The 11-day interval was probably too short to produce any major declines such as that for PCBs found earlier in big brown bats confined for 43 days (*3*).

RESIDUES COMPARED WITH AGE OF FEMALE

No correlations were found between age estimated by CTW and residues (total μg in females plus young, $n = 44$) of the PCB, DDE, DDT, oxychlordane, dieldrin, and *trans*-nonachlor, whereas PCB residues declined significantly with age in big brown bats (*2, 3*).

CAUSE OF STILLBIRTHS

Aroclor 1260 did not cause stillbirths in big brown bats, but high PCB levels and stillbirths were associated because both occurred more often in younger parent female bats (*2, 3*). In the present study, CTW and PCB concentrations were not correlated. Furthermore, when CTW for females with dead young (mean = 0.1169 ± 0.0213 mm, $n = 12$) was compared with CTW for females with live young (mean = 0.1217 ± 0.0130 mm,

$n = 31$), the difference was highly significant among big brown bats (*2*). Nevertheless, there appears to be an association between age and incidence of stillbirths. Among the neonates represented in Figure 1, there were seven small dead bats, less than 16 percent of the female parent's weight that had PCB concentrations equal to or less than 7 ppm. Five of the seven female parents of these bats showed no wear on their canines and were probably yearlings producing their first offspring. Among the 30 neonates that were heavier than 16 percent of the female's weight (Fig. 1), only nine showed no canine wear. The difference between these ratios is significant ($x^2 = 4.14$, $0.05 > p > 0.01$). Threfore, unknown reproductive difficulties associated with first pregnancies probably accounted for most of the young that were born dead. Beyond these, however, there remain the four dead young with the largest amounts of the PCB (12, 13, 18, and 25 ppm); none of their female parents was a yearling.

Therefore, high levels of the PCB may have caused four young bats to be born dead, but feeding studies with captive bats are needed to confirm this conclusion.

Acknowledgment

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SOILS

Pesticide Residue Levels in Soils and Crops, 1971— National Soils Monitoring Program (III)

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ABSTRACT

Data from the 1971 National Soils Monitoring Program are summarized. Composite samples of soil and mature crops were scheduled for collection from 1,533 4-hectare sites in 37 states. Analyses were performed on 1,486 soil samples for organochlorines, organophosphates, PCBs, and elemental arsenic; samples were analyzed for atrazine only when pesticide application data indicated current-year use. Organochlorine pesticides were detected in 45 percent of the soil samples in the following order of frequency: dieldrin, ΣDDT, aldrin, chlordane, and heptachlor epoxide. Most pesticide levels ranged from 0.01 to 0.25 ppm. Crop samples were collected from 729 sites, and all were analyzed for organochlorines. Crop samples were analyzed for organophosphates and atrazine only when pesticide application data indicated current-year use. Organochlorines were detected in 42 percent of the crop samples analyzed, organophosphates in 13 percent, and atrazine in 1 percent.

Introduction

The National Soils Monitoring Program is an integral part of the National Pesticide Monitoring Program (NPMP). The NPMP was initiated at the recommendation of the President's Science Advisory Committee in 1963 to determine levels and trends of pesticides and their degradation products in the environment (*4*). The Committee recommended that appropriate federal agencies "develop a continuing network to monitor residue levels in air, water, soil, man, wildlife and fish" (*1*). The U.S. Department of Agriculture (USDA) began monitoring agricultural soils in 1964. After a series of short-term monitoring projects (*5–7*), a nationwide agricultural soil monitoring program was designed (*9*) and tested (*10*). The USDA initiated widespread monitoring in 1968 (*11*) and 1969 (*3*).

The National Soils Monitoring Program was transferred to the U.S. Environmental Protection Agency (EPA), when EPA was created in 1970. The present report summarizes soil and crop pesticide concentration data collected in 1971 (fiscal year 1972) at 1,486 sampling sites in 37 states. Data were not collected from some larger western states because of budgetary limitations and because either those states have little widespread agriculture or they grow wheat and other small grains which require fewer pesticides than do nongrain crops.

Sampling Procedures

Site selection criteria and statistical design for the present study have been described by Wiersma et al. (*9*). During late summer and fall 1971, 1,486 sites in 37 states were sampled (Fig. 1). At each 4-hectare (10-acre) site, a composite soil sample and a composite mature crop sample were collected according to procedures described in the U.S. EPA Sample Collection Manual (*8*). Information on cropping practices and a history of pesticide application for the current cropping season were obtained in interviews with landowners or operators. These data have been summarized and published separately (*2*).

Analytical Procedures

ORGANOCHLORINES AND ORGANOPHOSPHATES

Sample Preparation, Soil—A 300-g subsample was taken from a thoroughly mixed field sample. The subsample was moistened with 80 ml water and extracted with 600 ml 3:1 hexane–isopropanol by concentric rotation for 4 hours. The isopropanol was removed by

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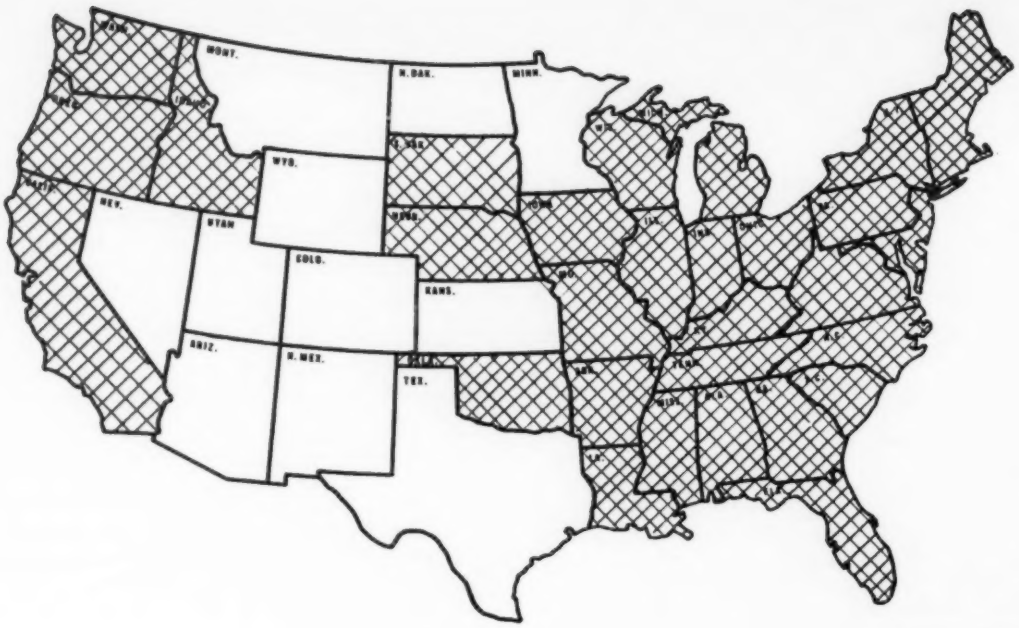

FIGURE 1. *States where agricultural soils and crops were sampled for the 1971 National Soils Monitoring Program, U.S. Environmental Protection Agency*

three distilled water washes, and the hexane extract was dried with anhydrous sodium sulfate. The sample extract was stored at low temperature for subsequent gas-liquid chromatographic analysis.

Sample Preparation, Crops—For samples containing less than 2 percent fat, e.g., alfalfa, bur clover, cornstalks, cotton stalks, green bolls, miscellaneous hay, a 100-g sample of the crop was blended with 25 ml distilled water for 3 minutes in 800 ml acetonitrile. An aliquot of the sample extract, representing 10 g of the original sample, was decanted into a 500-ml Erlemeyer flask. The sample extract was concentrated under a three-ball Snyder column to approximately 10 ml; 100 ml hexane was added, and the hexane–acetonitrile azeotrope was again concentrated to 10 ml. This process was carried out three times to remove the acetonitrile. The hexane extract was dried with anhydrous sodium sulfate, the volume was adjusted to 50 ml, and the extract was stored at low temperature until partitioning.

For crop samples containing more than 2 percent fat, e.g., corn kernels, cottonseed, soybeans, a 100-g sample was prewashed with 100 ml isopropanol and then with 100 ml hexane. Both prewashes were discarded. The prewashes were used to remove surface residues which may have contaminated the grain during removal of shells, husks, or pods, thus assuring that residues detected were actually contained in the grain. The sample was dried, dry blended, added to 100 ml isopropanol, and blended again. After 300 ml hexane was added, the isopropanol was removed by two washes with saturated aqueous NaCl solution and one wash with distilled water. The water–alcohol layers were discarded; the hexane layer was concentrated, adjusted to 50 ml, and held at low temperature until partitioning.

After extraction, crop samples were partitioned with hexane–acetonitrile as follows: 50 ml of the hexane sample extract, representing 10 g, was shaken with 100 ml acetonitrile in a 500-ml separatory funnel. The bottom acetonitrile layer was set aside. Another 100 ml acetonitrile was added to the hexane extract and the separation step described above was repeated twice; the hexane was discarded and the three acetonitrile layers were combined. The 300-ml acetonitrile extract, which contained essentially all the pesticides from the original hexane extract, was backwashed with 25 ml acetonitrile-saturated hexane, and the hexane layer was discarded. The acetonitrile sample extract was concentrated to approximately 10 ml under a three-ball Snyder column, and 100 ml hexane was added. This process was carried out three times to remove the acetonitrile. The

hexane extract was adjusted to 7.5 ml and stored at low temperature for subsequent Florisil column cleanup and fractionation.

A separate aliquot of the extract not subjected to Florisil cleanup was reserved for analysis for organophosphates by flame photometric detection.

Florisil Cleanup—An extract equivalent to 5 g original crop sample was fractionated through a 15-g Florisil column by use of 100 ml 10 percent methylene chloride in hexane and 100 ml methylene chloride for fractions one and two, respectively.

Methylene chloride was removed by concentration of each extract to low volume under a three-ball Snyder column, addition of 100 ml hexane, and concentration again to low volume. After two additions of hexane, the methylene chloride was essentially removed. Each extract volume was adjusted to 2.5 ml for separate injection on the gas-liquid chromatograph.

Gas-Liquid Chromatography—Gas chromatographs were equipped with tritium foil electron-affinity detectors for organochlorines and thermionic or flame photometric detectors for organophosphates. A multiple-column system with polar and nonpolar columns was used to identify compounds. Instrument parameters and operating conditions follow:

Gas chromatographs:	Hewlett Packard 402A Hewlett Packard 402B Tracor MT-220
Columns:	glass, 6 mm OD × 4 mm ID, 183 cm long, packed with 9 percent QF-1 on 100–120-mesh Gas-Chrom Q 3 percent DC-200 on 100–120-mesh Gas-Chrom Q a mixture of 1.5 percent OV-17 and 1.95 percent QF-1 on 100–120-mesh Supelcoport
Carrier gases:	5 percent methane-argon flowing at 80 ml/minute, prepurified nitrogen flowing at 80 ml/minute
Temperatures:	thermionic detector housing 250°C detector (EC and FPD) 200–210°C injection port 250°C columns 166°C 170–175°C 185–190°C

Minimum detection levels for organochlorines and trifluralin were 0.002–0.03 ppm except for combinations of polychlorinated biphenyls (PCBs), chlordane, toxaphene, and other chemicals which had minimum detectable levels of 0.05–0.1 ppm. Minimum detectable levels for organophosphates were approximately 0.01–0.03 ppm. The compounds detectable by the methodology of the present study are listed in Table 1. Trifluralin is detected by the organochlorine methodology and, for that reason, appears with the organochlorine analyses in the tables.

Recovery Studies—Pesticide recovery values from soil were 80–110 percent, but usually were close to 100 percent. Values from crops ranged from 70 to 100 percent, and varied with amount and type of pesticide and type of crop involved. Residues in both crop and soil samples were corrected for recovery. Soil samples were also corrected to a dry-weight basis.

TABLE 1. *Compounds detectable by chemical methodology of the present study, 1971—National Soils Monitoring Program*

ORGANOCHLORINES	
Alachlor	Endrin
Aldrin	Heptachlor
Chlordane	Heptachlor epoxide
o,p'-DDT	Isodrin
p,p'-DDT	Lindane (γ-BHC)
o,p'-DDE	Methoxychlor
p,p'-DDE	Ovex
o,p'-TDE	PCBs
p,p'-TDE	PCNs
Dieldrin	Propachlor
Endosulfan (I)	Toxaphene
Endosulfan (II)	
Endosulfan sulfate	
ORGANOPHOSPHATES	
DEF	Parathion, ethyl
Diazinon	Parathion, methyl
Ethion	Phorate
Malathion	Trithion
OTHER HALOGENS	
Trifluralin	

NOTE: Although trifluralin is a dinitroaniline compound, it is detected in the methodology used in the present study, and appears in Tables 1–7 under the Organochlorines heading.

ATRAZINE

A 50-g subsample was taken from a thoroughly mixed field sample. The subsample was extracted with 25 ml water and 300 ml methanol by concentric rotation for 4 hours. The sample extract was then decanted into a 1-liter separatory funnel and 200 ml water was added. The extract was partitioned with 150 ml Freon 113 three times. The Freon 113 fractions were combined and concentrated to incipient dryness. The extract was dissolved in hexane and adjusted to 5 ml for injection into a gas-liquid chromatograph equipped with a thermionic flame detector with a rubidium sulfate coating on a helix coil. Instrument parameters and operating conditions follow:

Column:	glass, 183 cm long × 6 mm OD × 4 mm ID, packed with 3 percent Versamid 900 on 100–120-mesh Gas-Chrom Q
Carrier gas:	helium
Detector fuel gases:	oxygen flowing at 200–300 ml/minute; hydrogen flowing at 20–30 ml/minute
Temperatures:	detector 200°C injection port 240°C column 240°C

Confirmatory analyses were performed on a DC-200 column at 180°C and a Coulson detector in the reductive mode at the following temperatures: pyrolysis tube, 850°C; transfer line, 220°C; and block, 220°C. Recovery was 90–110 percent with a minimum detection level of 0.01 ppm.

ARSENIC

Arsenic was determined by atomic absorption spectrophotometry. The soil sample was extracted with 9.6*N* HCl and arsenic was reduced to As^{+3} with $SnCl_2$. As^{+3} was partitioned from the acid to benzene, and then further partitioned from benzene into water for the absorption measurement. A Perkin-Elmer Model 303 spectrophotometer was used, and absorbance was measured with an arsenic cathode lamp at 1972 A with argon as an aspirant to an air–hydrogen flame. Minimum detection limit was 0.1 ppm, and recovery averaged 70 percent.

Results from all analyses were corrected for recovery and are expressed as ppm dry weight.

Results and Discussion

Tables presented in this report can be divided into two groups: those showing concentrations of pesticides in soil samples by all sites and states, and those showing concentrations of pesticides in mature agricultural crops. Most tables list the number of analyses, the number of times a compound was detected, the percent occurrence of the compound, the arithmetic mean, the estimated geometric mean, and the minimum and maximum positive concentrations detected.

The estimated geometric mean is routinely presented in the tables as an alternative to the arithmetic mean as a measure of central tendency for the data evaluation. Pesticide residue data frequently contain a large number of zero values, resulting either from the absence of pesticides or their presence at levels below the analytical sensitivity. Such data are seldom distributed normally, as shown by tests for skewness and kurtosis, but often approximate a log-normal distribution. After repeated tests for significant kurtosis and/or skewness, the $\log(X + 0.01)$ transformation was used to determine the logarithmic means. The antilogs of these figures minus 0.01 were taken to estimate the geometric mean in the untransformed dimension. The estimated geometric mean was calculated only for those compounds with more than one positive detection.

COMPOUND CONCENTRATIONS IN CROPLAND SOIL

All Sites—A total of 1,486 soil samples were received from 1,533 sites in 37 states, resulting in a 97 percent design completion. Results of analyses for organochlorines, organophosphates, triazines, and elemental arsenic are presented in Table 2. The most frequently detected pesticide was dieldrin, found in 27 percent of all samples analyzed. Next were ΣDDT, aldrin, chlordane, and

TABLE 2. *Compound concentrations in cropland soils for all sample sites in 37 states, 1971 (FY 1972)—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean	Estimated Geometric Mean[1]	Extremes of Detected Values	
					Min.	Max.
ORGANOCHLORINES, 1,486 SAMPLES						
Aldrin	144	9.7	0.02	0.002	0.01	1.88
Chlordane	119	8.0	0.06	0.003	0.01	6.98
o,p'-DDE	21	1.4	<0.01	<0.001	0.01	0.34
p,p'-DDE	334	22.5	0.11	0.007	0.01	54.98
o,p'-DDT	198	13.3	0.07	0.004	0.01	32.75
p,p'-DDT	305	20.5	0.37	0.010	0.01	245.18
o,p'-TDE	10	0.7	0.01	<0.001	0.02	16.79
p,p'-TDE	116	7.8	0.05	0.002	0.01	38.46
ΣDDT	356	24.0	0.61	0.013	0.01	388.16
Dieldrin	408	27.5	0.05	0.009	0.01	9.83
Endosulfan (I)	2	0.1	<0.01	<0.001	0.05	0.23
Endosulfan (II)	3	0.2	<0.01	<0.001	0.07	1.24
Endosulfan sulfate	3	0.2	<0.01	<0.001	0.16	2.07
Endrin	14	0.9	<0.01	<0.001	0.02	1.00
Heptachlor	73	4.9	0.01	0.001	0.01	1.37
Heptachlor epoxide	103	6.9	<0.01	0.001	0.01	0.43
Isodrin	3	0.2	<0.01	<0.001	0.01	0.02
Ovex	1	0.1	<0.01	—	1.13	—
Propachlor	3	0.2	<0.01	<0.001	0.07	0.10
Toxaphene	92	6.2	0.27	0.004	0.18	36.33
Trifluralin	52	3.5	<0.01	0.001	0.01	1.29
ORGANOPHOSPHATES, 1,141 SAMPLES						
DEF	4	0.4	<0.01	<0.001	0.15	0.66
Diazinon	4	0.4	<0.01	<0.001	0.02	0.05
Ethion	2	0.2	<0.01	<0.001	0.06	0.24
Malathion	1	0.1	<0.01	—	0.19	—
Parathion, ethyl	4	0.4	<0.01	<0.001	0.05	0.19
Phorate	1	0.1	<0.01	—	0.08	—
TRIAZINES, 213 SAMPLES						
Atrazine	152	71.4	0.23	0.052	0.01	16.73
HEAVY METALS, 1,474 SAMPLES						
Arsenic	1461	99.1	5.92	3.522	0.09	180.42

[1] Not calculated when fewer than two positive detections were present.

heptachlor epoxide, found in 24, 10, 8, and 7 percent of all samples analyzed, respectively.

Table 3 gives the occurrence of pesticide residues in the agricultural soil samples collected in 1971. The frequency of detection varied widely among the states surveyed. Atrazine detection frequencies are not comparable to the detection frequencies of other compounds because atrazine analyses were performed only when site application records indicated atrazine use during the current growing season.

Table 4 gives the percent incidence of residues of selected organochlorines at specific levels. For most compounds, the highest percentages of positive detections were in the 0.01–0.25-ppm category. Toxaphene was the exception; highest incidence of positive residues occurred in the >10.00-ppm category.

By State—Pesticide concentrations in soils of specific states or state groups are presented in Table 5. Because some of the smaller eastern states had very few sites, those with similar geographic locations and/or agricultural characteristics were combined to obtain more representative data. State groups used were: Mid-Atlantic: Delaware, Maryland, New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; Virginia and West Virginia.

Comparisons of the percent occurrence of aldrin, dieldrin heptachlor epoxide, ΣDDT, chlordane, and arsenic

TABLE 3. *Occurrence of organochlorine, organophosphate, and triazine residues in cropland soil, by state, 1971—National Soils Monitoring Program*

State	Organochlorines			Organophosphates			Triazines[1]		
	No. of Analyses	No. of Positive Detections	% of Positive Detections	No. of Analyses	No. of Positive Detections	% of Positive Detections	No. of Analyses	No. of Positive Detections	% of Positive Detections
Alabama	23	20	87	11	0	—	1	0	—
Arkansas	46	34	74	33	1	3	1	0	—
California	64	49	77	48	2	4	—	—	—
Florida	18	9	50	15	2	13	—	—	—
Georgia	30	3	10	15	0	—	—	—	—
Idaho	33	8	24	25	0	—	—	—	—
Illinois	142	102	72	93	3	3	23	20	87
Indiana	58	28	48	38	0	—	11	7	64
Iowa	152	108	71	104	0	—	54	44	81
Kentucky	31	3	10	31	0	—	6	5	83
Louisiana	26	20	77	12	0	—	—	—	—
Michigan	55	22	40	50	0	—	11	10	91
Mid-Atlantic	18	7	39	18	2	11	2	1	50
Mississippi	31	31	100	15	3	20	—	—	—
Missouri	80	31	39	67	0	—	20	13	65
Nebraska	106	32	30	99	2	2	21	17	81
New England	20	8	40	19	1	5	1	0	—
New York	38	12	32	35	0	—	6	6	100
North Carolina	31	27	87	7	0	—	—	—	—
Ohio	57	13	23	49	0	—	10	5	50
Oklahoma	64	7	11	58	0	—	1	1	100
Oregon	38	14	37	18	0	—	—	—	—
Pennsylvania	36	8	22	35	0	—	5	2	40
South Carolina	17	17	100	3	0	—	—	—	—
South Dakota	106	7	7	101	0	—	3	3	100
Tennessee	27	12	44	16	0	—	1	0	—
Virginia/West Virginia	27	12	44	25	0	—	—	—	—
Washington State	45	11	24	37	0	—	—	—	—
Wisconsin	67	7	10	64	0	—	36	18	50
TOTAL	1486	662	45	1141	16	1	213	152	71

[1] Samples analyzed only when application records indicated atrazine use during the current growing season.

TABLE 4. *Percent incidence of selected pesticides in cropland soil from all sampling sites in 37 states, 1971—National Soils Monitoring Program*

Concentration, ppm Dry Wt	ΣDDT[1]	Aldrin	Dieldrin	Chlordane	Heptachlor	Heptachlor Epoxide	Toxaphene	Trifluralin
Not Detected	76.0	90.3	72.5	92.0	95.1	93.1	93.8	96.5
0.01–0.25	11.2	7.9	22.3	3.4	4.4	6.7	0.1	3.2
0.26–1.00	6.3	1.3	4.8	3.1	0.4	0.2	1.1	0.2
1.01–5.00	5.1	0.5	0.3	1.4	0.1	—	3.4	0.1
5.01–10.00	0.7	—	0.1	0.1	—	—	1.0	—
>10.00	0.6	—	—	—	—	—	6.7	—
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] ΣDDT = *o,p'*-DDT + *p,p'*-DDT + *o,p'*-DDE + *p,p'*-DDE + *o,p'*-TDE + *p,p'*-TDE.

TABLE 5. *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values	
					Min.	Max.
ALABAMA, 23 SITES						
Organochlorines, 23 samples						
Chlordane	1	4.4	0.02	—	0.45	—
p,p'-DDE	18	78.3	0.10	0.044	0.01	0.33
o,p'-DDT	10	43.5	0.05	0.014	0.01	0.38
p,p'-DDT	16	69.6	0.26	0.065	0.01	1.39
ΣDDT	18	78.3	0.41	0.106	0.01	2.07
Dieldrin	4	17.4	<0.01	0.002	0.01	0.02
Endrin	1	4.4	0.02	—	0.42	—
Heptachlor	1	4.4	<0.01	—	0.07	—
Toxaphene	5	21.7	0.76	0.022	0.18	6.78
Organophosphates, 11 samples: no residues detected						
Triazines, 1 sample: no residues detected						
Heavy Metals, 23 samples						
Arsenic	23	100.0	2.84	1.855	0.39	8.13
ARKANSAS, 46 SITES						
Organochlorines, 46 samples						
Aldrin	2	4.4	<0.01	<0.001	0.01	0.02
o,p'-DDE	1	2.2	<0.01	—	0.03	—
p,p'-DDE	26	56.5	0.10	0.028	0.01	0.94
o,p'-DDT	14	30.4	0.07	0.099	0.01	0.95
p,p'-DDT	28	60.9	0.34	0.054	0.02	4.82
p,p'-TDE	15	32.6	0.07	0.012	0.01	1.03
ΣDDT	28	60.9	0.57	0.079	0.03	7.14
Dieldrin	15	32.6	0.02	0.009	0.02	0.18
Endrin	1	2.2	<0.01	—	0.10	—
Toxaphene	9	19.6	0.50	0.017	0.47	6.67
Trifluralin	2	4.4	<0.01	<0.001	0.05	0.06
Organophosphates, 33 samples						
Diazinon	1	3.0	<0.01	—	0.02	—
Triazines 1 sample: no residues detected						
Heavy Metals, 46 samples						
Arsenic	46	100.0	8.32	6.448	0.65	24.74
CALIFORNIA, 64 SITES						
Organochlorines, 64 samples						
Chlordane	1	1.6	0.04	—	2.45	—
o,p'-DDE	4	6.3	0.01	0.001	0.02	0.34
p,p'-DDE	45	70.3	0.15	0.050	0.01	0.87
o,p'-DDT	30	46.9	0.09	0.024	0.02	0.71
p,p'-DDT	39	60.9	0.33	0.064	0.01	2.53
o,p'-TDE	2	3.1	<0.01	0.001	0.01	0.20
p,p'-TDE	10	15.6	0.02	0.004	0.02	0.93
ΣDDT	47	73.4	0.61	0.123	0.01	3.88
Dieldrin	3	4.7	0.01	0.001	0.09	0.19
Endosulfan II	1	1.6	<0.01	—	0.18	—
Endosulfan sulfate	1	1.6	0.01	—	0.39	—
Heptachlor	1	1.6	<0.01	—	0.02	—
Heptachlor epoxide	1	1.6	<0.01	—	0.07	—
Ovex	1	1.6	0.02	—	1.13	—
Toxaphene	13	20.3	0.61	0.020	0.73	8.30
Trifluralin	3	4.7	0.03	0.002	0.10	1.29
Organophosphates, 48 samples						
Ethion	1	2.1	<0.01	—	0.24	—
Parathion, ethyl	1	2.1	<0.01	—	0.17	—
Heavy Metals, 54 samples						
Arsenic	54	100.0	5.26	3.802	0.72	19.14
FLORIDA, 18 SITES						
Organochlorines, 18 samples						
Aldrin	3	16.7	0.01	0.003	0.01	0.11
Chlordane	1	5.6	0.01	—	0.10	—
p,p'-DDE	6	33.3	0.04	0.011	0.02	0.42
o,p'-DDT	3	16.7	0.03	0.006	0.02	0.33
p,p'-DDT	6	33.3	0.10	0.015	0.04	1.14
p,p'-TDE	3	16.7	0.01	0.004	0.03	0.09
ΣDDT	7	38.9	0.19	0.025	0.02	1.89
Dieldrin	4	22.2	0.15	0.014	0.19	1.70
Endrin	2	11.1	0.06	0.004	0.02	1.00
Toxaphene	1	5.6	0.13	—	2.35	—
Organophosphates, 15 samples						
Ethion	1	6.7	<0.01	—	0.06	—
Parathion, ethyl	1	6.7	0.01	—	0.19	—
Heavy Metals, 18 samples						
Arsenic	16	88.9	1.49	0.575	0.12	10.11

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TABLE 5 (cont'd.). *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values	
					Min.	Max.
GEORGIA, 30 SITES						
Organochlorines, 30 samples						
Chlordane	3	10.0	0.02	0.003	0.14	0.21
o,p'-DDE	1	3.3	<0.01	—	0.02	—
p,p'-DDE	25	83.3	0.14	0.062	0.01	0.83
o,p'-DDT	14	46.7	0.07	0.019	0.01	0.63
p,p'-DDT	22	73.3	0.35	0.093	0.01	2.70
o,p'-TDE	1	3.3	<0.01	—	0.03	—
p,p'-TDE	11	36.7	0.03	0.010	0.02	0.26
ΣDDT	25	83.3	0.59	0.172	0.01	4.42
Dieldrin	7	23.3	0.04	0.007	0.01	0.45
Heptachlor epoxide	2	6.7	<0.01	0.001	0.01	0.04
Toxaphene	9	30.0	1.25	0.046	1.06	10.20
Trifluralin	1	3.3	0.01	—	0.21	—
Organophosphates, 15 samples: no residues detected						
Heavy Metals, 30 samples						
Arsenic	30	100.0	1.64	1.116	0.20	6.99
IDAHO, 33 SITES						
Organochlorines, 33 samples						
p,p'-DDE	9	27.3	0.03	0.008	0.02	0.41
o,p'-DDT	4	12.1	0.01	0.002	0.02	0.27
p,p'-DDT	8	24.2	0.13	0.009	0.01	3.23
p,p'-TDE	1	3.0	<0.01	—	0.08	—
ΣDDT	9	27.3	0.18	0.013	0.04	3.99
Dieldrin	4	12.1	<0.01	0.002	0.01	0.03
Toxaphene	1	3.0	0.15	—	4.96	—
Trifluralin	2	6.1	<0.01	0.001	0.06	0.07
Organophosphates, 25 samples: no residues detected						
Heavy Metals, 31 samples						
Arsenic	31	100.0	2.17	1.785	0.30	4.99
ILLINOIS, 142 SITES						
Organochlorines, 142 samples						
Aldrin	54	38.0	0.06	0.011	0.01	1.83
Chlordane	46	31.7	0.47	0.027	0.04	6.98
p,p'-DDE	2	1.4	<0.01	<0.001	0.01	0.06
p,p'-DDT	4	2.8	<0.01	0.001	0.04	0.10
ΣDDT	5	3.5	<0.01	0.001	0.01	0.16
Dieldrin	96	66.9	0.14	0.050	0.01	0.75
Heptachlor	39	27.5	0.04	0.008	0.01	1.37
Heptachlor epoxide	45	31.7	0.02	0.008	0.01	0.34
Propachlor	2	1.4	<0.01	<0.001	0.10	—
Trifluralin	7	4.9	<0.01	0.001	0.02	0.15
Organophosphates, 93 samples						
Diazinon	1	1.1	<0.01	—	0.05	—
Malathion	1	1.1	<0.01	—	0.19	—
Phorate	1	1.1	<0.01	—	0.08	—
Triazines, 23 samples						
Atrazine	20	87.0	0.22	0.102	0.03	0.92
Heavy Metals, 141 samples						
Arsenic	141	100.0	7.8	5.950	0.86	28.22
INDIANA, 58 SITES						
Organochlorines, 58 samples						
Aldrin	14	24.1	0.08	0.009	0.01	1.64
Chlordane	6	10.3	0.12	0.006	0.16	4.10
o,p'-DDE	1	1.7	<0.01	—	0.02	—
p,p'-DDE	6	10.3	0.01	0.002	0.02	0.25
o,p'-DDT	2	3.5	<0.01	0.001	0.02	0.08
p,p'-DDT	4	6.9	0.01	0.002	0.02	0.56
p,p'-TDE	2	3.5	0.01	0.001	0.06	0.27
ΣDDT	6	10.3	0.03	0.004	0.04	0.89
Dieldrin	22	37.9	0.10	0.019	0.01	0.85
Endosulfan	1	1.7	<0.01	—	0.05	—
Endosulfan II	1	1.7	<0.01	—	0.07	—
Endosulfan sulfate	1	1.7	<0.01	—	0.16	—
Heptachlor	5	8.6	0.01	0.002	0.01	0.20
Heptachlor epoxide	5	8.6	0.01	0.002	0.01	0.43
Isodrin	1	1.7	<0.01	—	0.01	—
Trifluralin	3	5.2	<0.01	0.001	0.03	0.13
Organophosphates, 38 samples: no residues detected						
Triazines, 11 samples						
Atrazine	7	63.6	0.05	0.020	0.01	0.27
Heavy Metals, 58 samples						
Arsenic	58	100.0	4.66	3.478	0.42	15.93

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TABLE 5 (cont'd.). *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values	
					Min.	Max.
IOWA, 152 SITES						
Organochlorines, 152 samples						
Aldrin	43	28.3	0.04	0.008	0.01	1.01
Chlordane	20	13.2	0.06	0.006	0.02	1.63
o,p'-DDE	1	0.7	<0.01	—	0.01	—
p,p'-DDE	17	11.2	0.01	0.002	0.01	0.19
o,p'-DDT	5	3.3	<0.01	0.001	0.02	0.24
p,p'-DDT	19	12.5	0.02	0.003	0.02	1.42
p,p'-TDE	3	2.0	<0.01	<0.001	0.01	0.04
ΣDDT	22	14.5	0.03	0.004	0.01	1.59
Dieldrin	97	63.8	0.09	0.033	0.01	0.79
Heptachlor	13	8.6	<0.01	0.001	0.01	0.15
Heptachlor epoxide	18	11.8	0.01	0.002	0.01	0.16
Isodrin	2	1.3	<0.01	<0.001	0.02	—
Toxaphene	1	0.7	0.04	—	5.97	—
Trifluralin	15	9.87	0.01	0.002	0.01	0.40
Organophosphates, 104 samples: no residues detected						
Triazines, 54 samples						
Atrazine	44	81.5	0.62	0.135	0.02	16.73
Heavy Metals, 152 samples						
Arsenic	151	99.3	6.3	4.574	0.24	26.05
KENTUCKY, 31 SITES						
Organochlorines, 31 samples						
Aldrin	1	3.2	<0.01	—	0.01	—
Chlordane	1	3.2	0.08	—	2.47	—
p,p'-DDE	2	6.5	<0.01	0.001	0.01	0.05
p,p'-DDT	1	3.2	<0.01	—	0.01	—
p,p'-TDE	1	3.2	<0.01	—	0.02	—
ΣDDT	2	6.5	<0.01	0.001	0.02	0.07
Dieldrin	1	3.2	0.02	—	0.48	—
Endosulfan	1	3.2	0.01	—	0.23	—
Endosulfan II	1	3.2	0.04	—	1.24	—
Endosulfan sulfate	1	3.2	0.07	—	2.07	—
Toxaphene	1	3.2	0.06	—	1.80	—
Organophosphates, 31 samples: no residues detected						
Triazines, 6 samples						
Atrazine	5	83.3	0.03	0.022	0.02	0.05
Heavy Metals, 31 samples						
Arsenic	31	100.0	9.25	5.608	0.74	29.31
LOUISIANA, 26 SITES						
Organochlorines, 26 samples						
Aldrin	1	3.9	<0.01	—	0.03	—
Chlordane	2	7.7	0.01	0.002	0.06	0.26
o,p'-DDE	1	3.9	0.01	—	0.25	—
p,p'-DDE	11	42.3	0.25	0.033	0.03	2.23
o,p'-DDT	10	38.5	0.24	0.020	0.01	3.66
p,p'-DDT	11	42.3	0.79	0.046	0.01	7.41
p,p'-TDE	8	30.8	0.12	0.014	0.02	1.67
ΣDDT	11	42.3	1.41	0.067	0.05	15.22
Dieldrin	7	26.9	0.02	0.006	0.01	0.15
Toxaphene	8	30.8	3.02	0.057	0.68	36.33
Trifluralin	2	7.7	0.02	0.003	0.11	0.37
Organophosphates, 12 samples: no residues detected						
Heavy Metals, 26 samples						
Arsenic	25	96.2	4.09	2.541	0.41	10.77
MICHIGAN, 55 SITES						
Organochlorines, 55 samples						
Aldrin	4	7.3	0.02	0.002	0.07	0.52
Chlordane	7	12.7	0.02	0.004	0.02	0.37
p,p'-DDE	9	16.4	0.11	0.006	0.01	4.35
o,p'-DDT	6	10.9	0.04	0.004	0.02	1.45
p,p'-DDT	8	14.6	0.22	0.007	0.02	8.20
p,p'-TDE	2	3.6	0.01	0.001	0.04	0.72
ΣDDT	9	16.4	0.38	0.008	0.02	14.72
Dieldrin	16	29.1	0.02	0.007	0.01	0.34
Heptachlor	1	1.8	<0.01	—	0.01	—
Heptachlor epoxide	3	5.5	<0.01	0.001	0.01	0.06
Trifluralin	1	1.8	<0.01	—	0.10	—
Organophosphates, 50 samples: no residues detected						
Triazines, 11 samples						
Atrazine	10	90.9	0.09	0.068	0.02	0.25
Heavy Metals, 55 samples						
Arsenic	55	100.0	8.26	4.763	0.55	73.65

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TABLE 5 (cont'd.). *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values	
					Min.	Max.
MID-ATLANTIC[2], 18 SITES						
Organochlorines, 18 samples						
Aldrin	1	5.6	<0.01	—	0.05	—
Chlordane	1	5.6	<0.01	—	0.06	—
o,p'-DDE	1	5.6	<0.01	—	0.03	—
p,p'-DDE	3	16.7	0.04	0.005	0.04	0.61
o,p'-DDT	1	5.6	0.01	—	0.16	—
p,p'-DDT	2	11.1	0.04	0.004	0.08	0.71
o,p'-TDE	1	5.6	0.01	—	0.11	—
ΣDDT	3	16.7	0.10	0.007	0.04	1.62
Dieldrin	5	27.8	0.02	0.007	0.03	0.09
Heptachlor epoxide	2	11.1	0.01	0.001	0.01	—
Organophosphates, 18 samples						
Diazinon	1	5.6	<0.01	—	0.03	—
Parathion, ethyl	1	5.6	<0.01	—	0.05	—
Triazines, 2 samples						
Atrazine	1	50.0	0.03	—	0.07	—
Heavy Metals, 18 samples						
Arsenic	18	100.0	3.83	2.652	0.43	18.01
MISSISSIPPI, 31 SITES						
Organochlorines, 31 samples						
p,p'-DDE	30	96.8	0.29	0.152	0.01	1.26
o,p'-DDT	26	83.9	0.41	0.203	0.01	1.73
p,p'-DDT	30	96.8	1.98	0.611	0.01	16.07
p,p'-TDE	11	35.5	0.08	0.015	0.02	1.16
ΣDDT	30	96.8	2.68	0.922	0.02	19.97
Dieldrin	6	19.4	0.01	0.003	0.01	0.10
Endrin	2	6.5	0.02	0.002	0.02	0.64
Toxaphene	22	71.0	3.82	0.579	0.46	21.00
Trifluralin	9	29.0	0.01	0.006	0.02	0.15
Organophosphates, 15 samples						
DEF	3	20.0	0.08	0.010	0.15	0.66
Heavy Metals, 31 samples						
Arsenic	31	100.0	9.65	7.726	1.10	20.15
MISSOURI, 80 SITES						
Organochlorines, 80 samples						
Aldrin	7	8.8	0.03	0.002	0.01	1.88
Chlordane	5	6.3	0.03	0.002	0.09	1.09
o,p'-DDE	1	1.3	<0.01	—	0.09	—
p,p'-DDE	4	5.0	<0.01	0.001	0.01	0.06
o,p'-DDT	1	1.3	<0.01	—	0.05	—
p,p'-DDT	5	6.3	0.01	0.002	0.03	0.33
ΣDDT	7	8.8	0.02	0.003	0.01	0.47
Dieldrin	25	31.3	0.07	0.014	0.01	0.78
Heptachlor	4	5.0	<0.01	0.001	0.01	0.07
Heptachlor epoxide	6	7.5	<0.01	0.001	0.02	0.10
Propachlor	1	1.3	<0.01	—	0.07	—
Trifluralin	3	3.8	<0.01	0.001	0.02	0.13
Organophosphates, 67 samples: no residues detected						
Triazines, 20 samples						
Atrazine	13	65.0	0.06	0.026	0.01	0.34
Heavy Metals, 80 samples						
Arsenic	80	100.0	5.02	3.739	0.88	21.86
NEBRASKA, 106 SITES						
Organochlorines, 106 samples						
Aldrin	1	0.9	<0.01	—	0.02	—
Chlordane	8	7.6	0.02	0.002	0.02	0.71
o,p'-DDE	1	0.9	<0.01	—	0.02	—
p,p'-DDE	4	3.8	0.01	0.001	0.02	0.55
o,p'-DDT	2	1.9	<0.01	0.001	0.02	0.41
p,p'-DDT	5	4.7	0.02	0.002	0.01	1.35
ΣDDT	5	4.7	0.03	0.002	0.03	2.33
Dieldrin	32	30.2	0.02	0.008	0.01	0.31
Endrin	2	1.9	<0.01	<0.001	0.06	0.08
Heptachlor	3	2.8	0.01	<0.001	0.01	—
Heptachlor epoxide	9	8.5	0.01	0.001	0.01	0.07
Organophosphates, 99 samples						
DEF	1	1.0	<0.01	—	0.20	—
Diazinon	1	1.0	<0.01	—	0.03	—
Triazines, 21 samples						
Atrazine	17	81.0	0.07	0.042	0.02	0.28
Heavy Metals, 106 samples						
Arsenic	104	98.1	5.24	3.282	0.41	18.37

(*Continued next page*)

TABLE 5 (cont'd.). *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight: Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values: Min.	Max.
NEW ENGLAND[2], 20 SITES						
Organochlorines, 20 samples						
Aldrin	1	5.0	0.01	—	0.28	—
Chlordane	1	5.0	0.11	—	2.20	—
p,p'-DDE	6	30.0	0.07	0.014	0.06	0.44
o,p'-DDT	4	20.0	0.02	0.006	0.05	0.22
p,p'-DDT	6	30.0	0.16	0.019	0.03	0.90
o,p'-TDE	1	5.0	<0.01	—	0.05	—
p,p'-TDE	5	25.0	0.07	0.010	0.02	0.92
ΣDDT	6	30.0	0.32	0.026	0.09	2.16
Dieldrin	3	15.0	0.17	0.006	0.03	3.26
Heptachlor	1	5.0	<0.01	—	0.04	—
Heptachlor epoxide	1	5.0	<0.01	—	0.03	—
Organophosphates, 19 samples						
Parathion, ethyl	1	5.3	0.01	—	0.14	—
Triazines, 1 sample: no residues detected						
Heavy Metals, 20 samples						
Arsenic	19	95.0	8.56	2.841	0.60	69.10
NEW YORK, 38 SITES						
Organochlorines, 38 samples						
Chlordane	2	5.3	0.01	0.002	0.11	0.40
o,p'-DDE	1	2.6	<0.01	—	0.10	—
p,p'-DDE	11	29.0	1.74	0.016	0.01	54.98
o,p'-DDT	7	18.4	1.31	0.013	0.01	32.75
p,p'-DDT	10	26.3	7.69	0.022	0.02	245.18
o,p'-TDE	2	5.3	0.45	0.003	0.23	16.79
p,p'-TDE	5	13.2	1.07	0.008	0.11	38.46
Σ DDT	11	29.0	12.26	0.028	0.02	388.16
Dieldrin	4	10.5	0.28	0.005	0.03	9.83
Heptachlor epoxide	1	2.6	<0.01	—	0.03	—
Trifluralin	1	2.6	<0.01	—	0.14	—
Organophosphates, 35 samples: no residues detected						
Triazines, 6 samples						
Atrazine	6	100.0	0.18	0.136	0.04	0.38
Heavy Metals, 38 samples						
Arsenic	38	100.0	11.63	5.466	0.41	180.42
NORTH CAROLINA, 31 SITES						
Organochlorines, 31 samples						
Aldrin	1	3.2	<0.01	—	0.04	—
Chlordane	2	6.5	0.05	0.003	0.37	1.06
o,p'-DDE	2	6.5	<0.01	0.001	0.01	0.05
p,p'-DDE	25	80.7	0.08	0.043	0.01	0.50
o,p'-DDT	18	58.1	0.05	0.022	0.01	0.51
p,p'-DDT	25	80.7	0.27	0.087	0.01	2.62
p,p'-TDE	18	58.1	0.05	0.024	0.03	0.23
ΣDDT	26	83.9	0.46	0.169	0.02	3.63
Dieldrin	14	54.2	0.04	0.015	0.01	0.13
Endrin	1	3.2	<0.01	—	0.03	—
Heptachlor	1	3.2	0.01	—	0.34	—
Heptachlor epoxide	1	3.2	<0.01	—	0.08	—
Toxaphene	7	22.6	0.65	0.022	0.51	12.00
Organophosphates, 7 samples: no residues detected						
Heavy Metals, 31 samples						
Arsenic	28	90.3	2.41	0.996	0.38	17.95
OHIO, 57 SITES						
Organochlorines, 57 samples						
Aldrin	4	7.0	0.01	0.002	0.02	0.33
Chlordane	3	5.3	0.02	0.002	0.05	0.86
p,p'-DDE	4	7.0	0.12	0.003	0.04	4.55
o,p'-DDT	2	3.5	0.07	0.002	0.15	3.79
p,p'-DDT	4	7.0	0.51	0.004	0.06	23.70
o,p'-TDE	1	1.8	<0.01	—	0.05	—
p,p'-TDE	3	5.3	0.06	0.002	0.05	2.07
ΣDDT	5	8.8	0.76	0.005	0.04	34.11
Dieldrin	6	10.5	0.02	0.004	0.06	0.46
Heptachlor	1	1.8	<0.01	—	0.14	—
Heptachlor epoxide	2	3.5	<0.01	<0.001	0.01	0.04
Trifluralin	1	1.8	<0.01	—	0.10	—
Organophosphates, 49 samples: no residues detected						
Triazines, 10 samples						
Atrazine	5	50.0	0.25	0.047	0.05	1.38
Heavy Metals, 57 samples						
Arsenic	57	100.0	14.17	9.858	1.11	48.97

(*Continued next page*)

TABLE 5 (cont'd.). *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values	
					Min.	Max.
OKLAHOMA, 65 SITES						
Organochlorines, 64 samples						
o,p'-DDE	1	1.6	<0.01	—	0.03	—
p,p'-DDE	5	7.8	0.03	0.002	0.01	1.72
o,p'-DDT	1	1.6	<0.01	—	0.03	—
p,p'-DDT	3	4.7	0.01	0.001	0.01	0.85
p,p'-TDE	1	1.6	<0.01	—	0.12	—
ΣDDT	6	9.4	0.05	0.002	0.01	3.02
Dieldrin	2	3.1	<0.01	0.001	0.08	0.23
Endrin	1	1.6	<0.01	—	0.05	—
Organophosphates, 58 samples: no residues detected						
Triazines, 1 sample						
Atrazine	1	100.0	0.05	—	0.05	—
Heavy Metals, 65 samples						
Arsenic	64	98.5	2.66	1.872	0.32	10.08
OREGON, 38 SITES						
Organochlorines, 38 samples						
Aldrin	2	5.3	<0.01	0.001	0.02	—
o,p'-DDE	1	2.6	<0.01	—	0.01	—
p,p'-DDE	12	31.6	0.45	0.008	0.01	16.69
o,p'-DDT	6	15.8	0.12	0.003	0.01	4.51
p,p'-DDT	6	15.8	0.49	0.006	0.03	18.20
p,p'-TDE	2	5.3	<0.01	0.001	0.01	0.10
ΣDDT	12	31.6	1.07	0.011	0.01	39.40
Dieldrin	6	15.8	0.07	0.006	0.06	2.15
Endrin	2	5.3	<0.01	0.009	0.03	—
Heptachlor epoxide	1	2.6	<0.01	—	0.01	—
Organophosphates, 18 samples: no residues detected						
Heavy Metals, 38 samples						
Arsenic	38	100.0	5.04	2.830	0.38	61.81
PENNSYLVANIA, 36 SITES						
Organochlorines, 36 samples						
Aldrin	1	2.8	<0.01	—	0.15	—
p,p'-DDE	3	8.3	0.01	0.002	0.05	0.14
o,p'-DDT	1	2.8	<0.01	—	0.01	—
p,p'-DDT	3	8.3	0.01	0.002	0.02	0.15
ΣDDT	3	8.3	0.01	0.003	0.07	0.30
Dieldrin	5	13.9	0.02	0.003	0.01	0.49
Endrin	1	2.8	<0.01	—	0.06	—
Organophosphates, 35 samples: no residues detected						
Triazines, 5 samples						
Atrazine	2	40.0	0.02	0.009	0.03	0.05
Heavy Metals, 36 samples						
Arsenic	36	100.0	6.83	5.979	1.96	17.19
SOUTH CAROLINA, 17 SITES						
Organochlorines, 17 samples						
Aldrin	1	5.9	<0.01	—	0.01	—
p,p'-DDE	17	100.0	0.24	0.182	0.01	0.47
o,p'-DDT	15	88.2	0.23	0.127	0.02	0.91
p,p'-DDT	17	100.0	0.85	0.544	0.05	3.38
p,p'-TDE	4	23.5	0.08	0.012	0.12	0.55
ΣDDT	17	100.0	1.40	0.908	0.06	4.65
Dieldrin	6	35.3	0.11	0.014	0.02	1.42
Toxaphene	13	76.5	3.17	0.636	0.49	18.10
Organophosphates, 3 samples: no residues detected						
Heavy Metals, 17 samples						
Arsenic	17	100.0	1.75	1.085	0.13	9.59
SOUTH DAKOTA, 106 SITES						
Organochlorines, 106 samples						
Aldrin	1	0.9	<0.01	—	0.08	—
Chlordane	4	3.8	0.01	0.001	0.03	0.36
p,p'-DDE	1	0.9	<0.01	—	0.01	—
p,p'-DDT	1	0.9	<0.01	—	0.01	—
ΣDDT	1	0.9	<0.01	—	0.02	—
Dieldrin	5	4.7	<0.01	0.001	0.01	0.27
Heptachlor epoxide	4	3.8	<0.01	0.001	0.01	0.05
Organophosphates, 101 samples: no residues detected						
Triazines, 3 samples						
Atrazine	3	100.0	0.19	0.166	0.09	0.31
Heavy Metals, 106 samples						
Arsenic	105	99.1	6.04	5.231	0.90	31.05

(*Continued next page*)

TABLE 5 (cont'd.). *Compound concentrations in cropland soil, by state, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight: Arithmetic Mean Concentration	Geometric Mean Concentration[1]	Extremes of Detected Values: Min.	Max.
TENNESSEE, 27 SITES						
Organochlorines, 27 samples						
Chlordane	1	3.7	0.02	—	0.49	—
p,p'-DDE	9	33.3	0.09	0.013	0.01	1.28
o,p'-DDT	7	25.9	0.03	0.009	0.01	0.23
p,p'-DDT	10	37.0	0.17	0.022	0.01	1.59
p,p'-TDE	4	14.8	0.01	0.003	0.02	0.15
ΣDDT	11	40.7	0.30	0.030	0.01	2.29
Dieldrin	1	3.7	<0.01	—	0.02	—
Heptachlor	1	3.7	<0.01	—	0.02	—
Heptachlor epoxide	1	3.7	<0.01	—	0.12	—
Toxaphene	2	7.4	0.16	0.005	2.06	2.14
Trifluralin	2	7.4	<0.01	0.001	0.01	—
Organophosphates, 16 samples: no residues detected						
Triazines, 1 sample: no residues detected						
Heavy Metals, 27 samples						
Arsenic	27	100.0	8.52	7.114	1.53	16.78
VIRGINIA/WEST VIRGINIA[2], 27 SITES						
Organochlorines, 27 samples						
Chlordane	1	3.7	0.03	—	0.83	—
o,p'-DDE	2	7.4	0.01	0.001	0.01	0.14
p,p'-DDE	9	33.3	0.21	0.010	0.02	5.41
o,p'-DDT	3	11.1	0.02	0.003	0.03	0.36
p,p'-DDT	5	18.5	0.16	0.007	0.03	3.78
o,p'-TDE	2	7.4	0.05	0.003	0.12	1.35
p,p'-TDE	5	18.5	0.29	0.006	0.02	7.47
ΣDDT	9	33.3	0.74	0.017	0.02	18.51
Dieldrin	5	18.5	0.01	0.003	0.01	0.08
Endrin	1	3.7	0.02	—	0.51	—
Heptachlor	1	3.7	<0.01	—	0.12	—
Heptachlor epoxide	1	3.7	<0.01	—	0.08	—
Organophosphates, 25 samples: no residues detected						
Heavy Metals, 27 samples						
Arsenic	27	100.0	3.48	2.081	0.41	16.66
WASHINGTON STATE, 45 SITES						
Organochlorines, 45 samples						
Aldrin	2	4.4	<0.01	0.001	0.01	0.03
Chlordane	2	4.4	0.01	0.001	0.01	0.45
o,p'-DDE	2	4.4	<0.01	0.001	0.01	0.06
p,p'-DDE	10	22.2	0.11	0.007	0.01	2.74
o,p'-DDT	4	8.9	0.02	0.003	0.10	0.48
p,p'-DDT	5	11.1	0.21	0.008	0.53	3.21
p,p'-TDE	2	4.4	0.04	0.002	0.07	1.83
ΣDDT	10	22.2	0.39	0.011	0.01	7.46
Dieldrin	4	8.9	<0.01	0.001	0.02	0.04
Organophosphates, 37 samples: no residues detected						
Heavy Metals, 45 samples						
Arsenic	45	100.0	3.29	2.279	0.64	32.07
WISCONSIN, 67 SITES						
Organochlorines, 67 samples						
Chlordane	1	1.5	<0.01	—	0.03	—
p,p'-DDE	5	7.5	0.01	0.002	0.01	0.32
o,p'-DDT	2	3.0	<0.01	0.001	0.13	0.20
p,p'-DDT	2	3.0	0.02	0.001	0.51	0.94
ΣDDT	5	7.5	0.04	0.002	0.01	1.46
Dieldrin	3	4.5	<0.01	0.001	0.07	0.15
Heptachlor	1	1.5	<0.01	—	0.01	—
Organophosphates, 64 samples: no residues detected						
Triazines, 36 samples						
Atrazine	18	50.0	0.06	0.020	0.01	0.63
Heavy Metals, 67 samples						
Arsenic	66	98.5	1.53	1.039	0.09	12.66

[1] Not calculated when fewer than two positive detections were present.

[2] Some smaller eastern states with few sites, but which have similar geographic locations and/or agricultural characteristics were combined to obtain more representative data including: Mid-Atlantic states: Delaware, Maryland, New Jersey. New England states: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; Virginia/West Virginia.

are presented in Figures 2–7. The key for each figure is based on the arithmetic average percent occurrence ($\bar{x}$) of the compound for all sites. The four classes are described as: greater than $2\bar{x}$; greater than $\bar{x}$ but less than $2\bar{x}$; greater than $\frac{1}{2}\bar{x}$ but less than $\bar{x}$; and less than $\frac{1}{2}\bar{x}$.

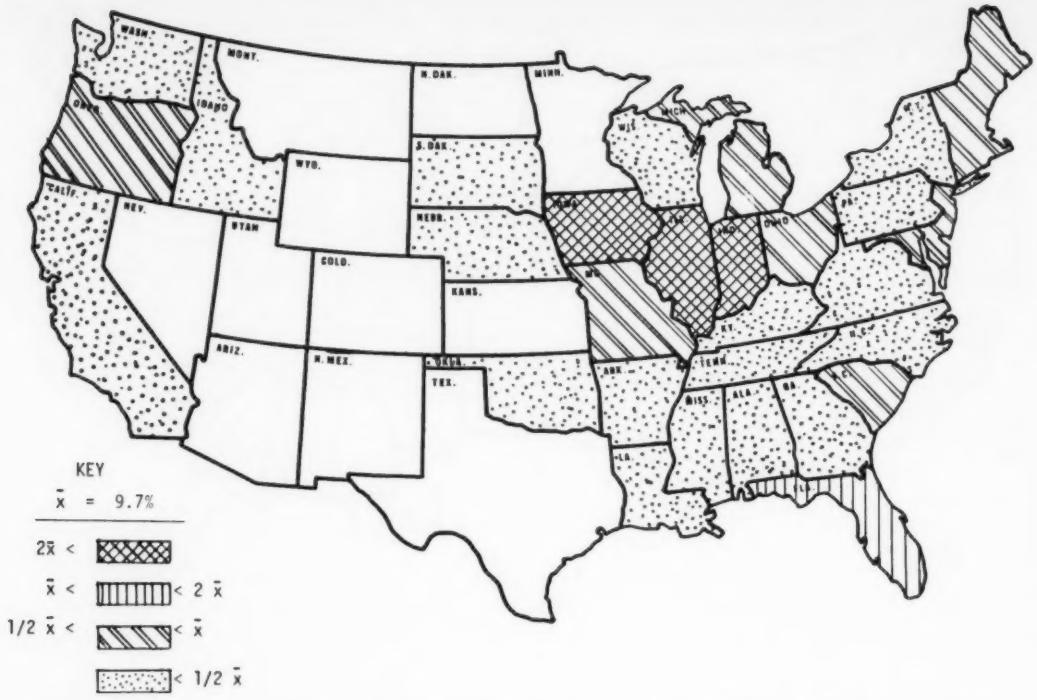

FIGURE 2. *Percent occurrence of aldrin residue detections in cropland soil, by state, 1971, National Soils Monitoring Program, U.S. Environmental Protection Agency*

FIGURE 3. *Percent occurrence of dieldrin residue detections in cropland soil, by state, 1971, National Soils Monitoring Program, U.S. Environmental Protection Agency*

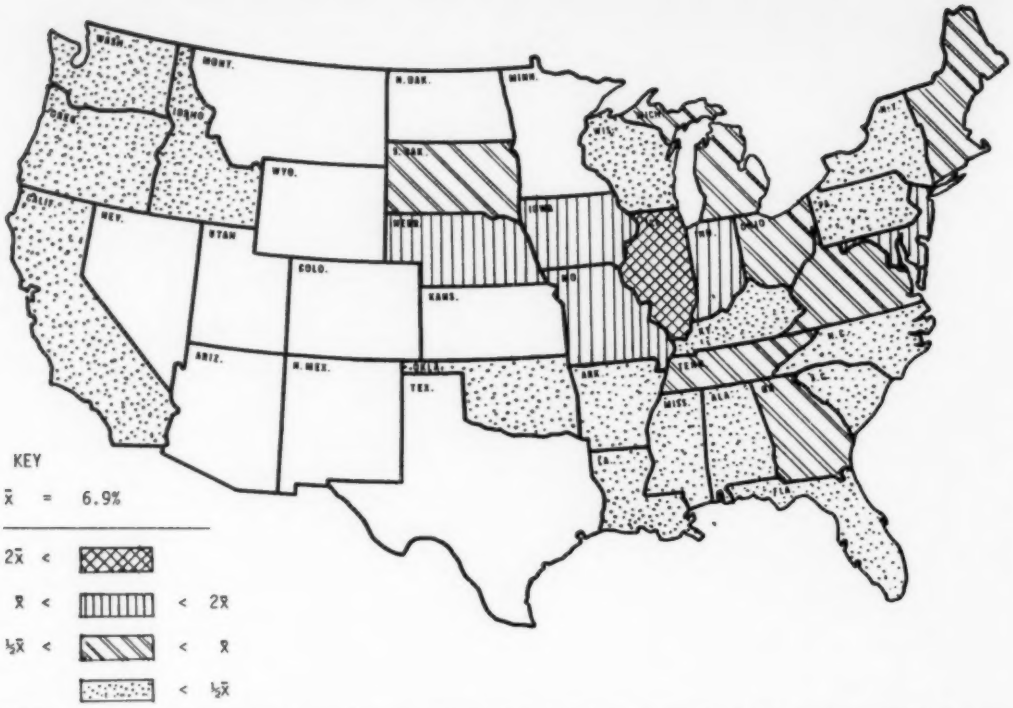

FIGURE 4. *Percent occurrence of heptachlor epoxide residue detections in cropland soil, by state, 1971, National Soils Monitoring Program, U.S. Environmental Protection Agency*

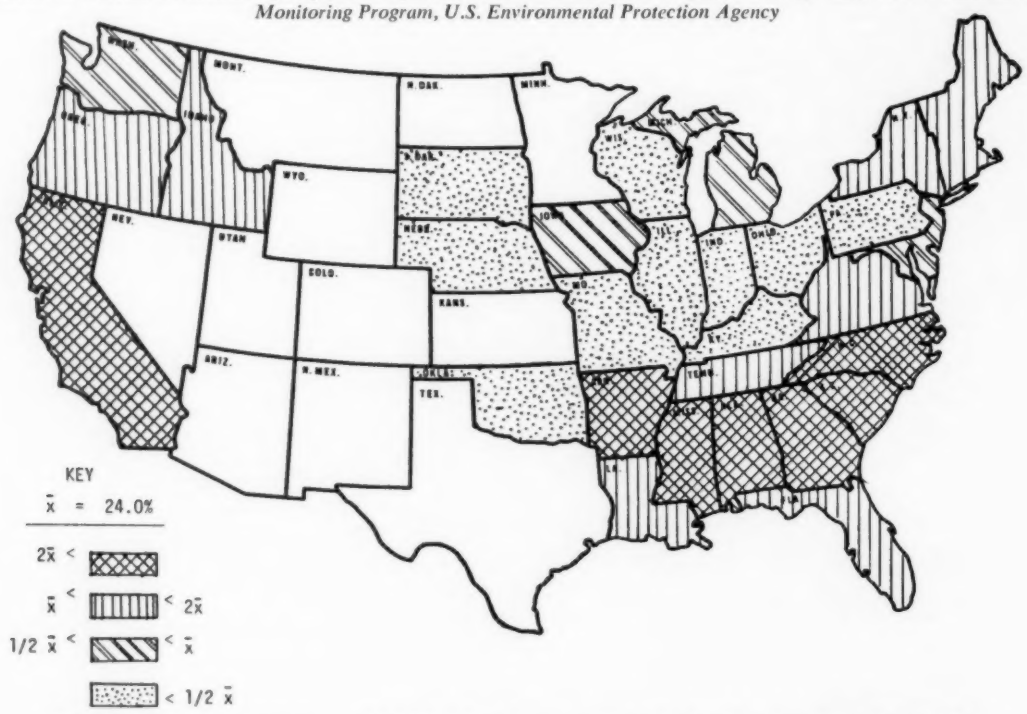

FIGURE 5. *Percent occurrence of ΣDDT residue detections in cropland soil, by state 1971, National Soils Monitoring Program, U.S. Environmental Protection Agency*

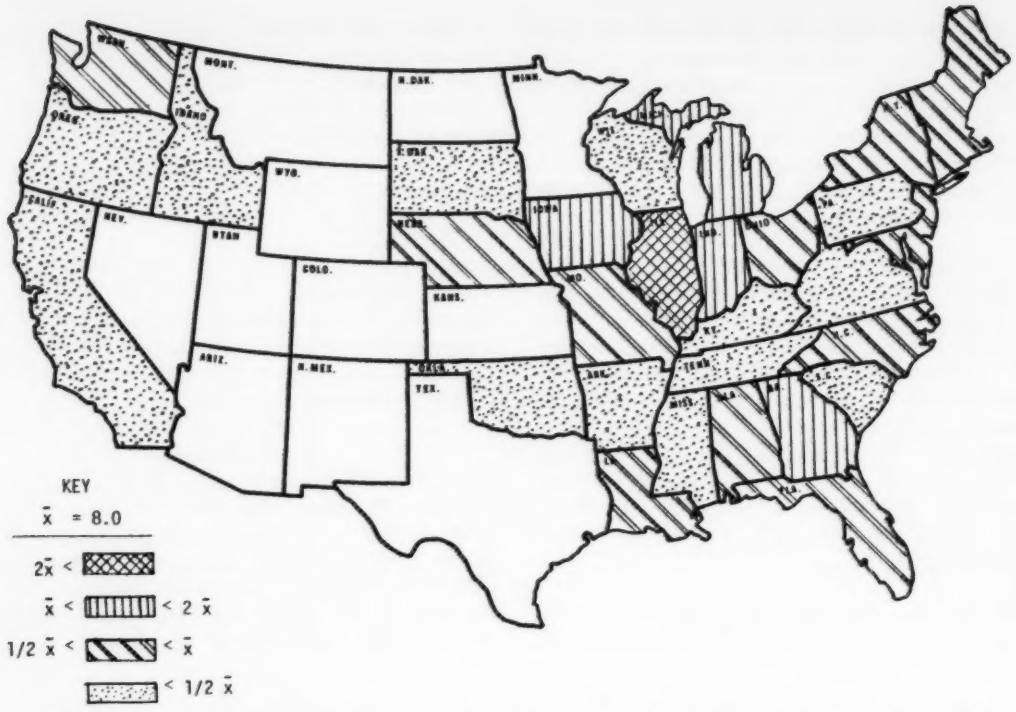

FIGURE 6. *Percent occurrence of chlordane residue detections in cropland soil, by state, 1971, National Soils Monitoring Program, U.S. Environmental Protection Agency*

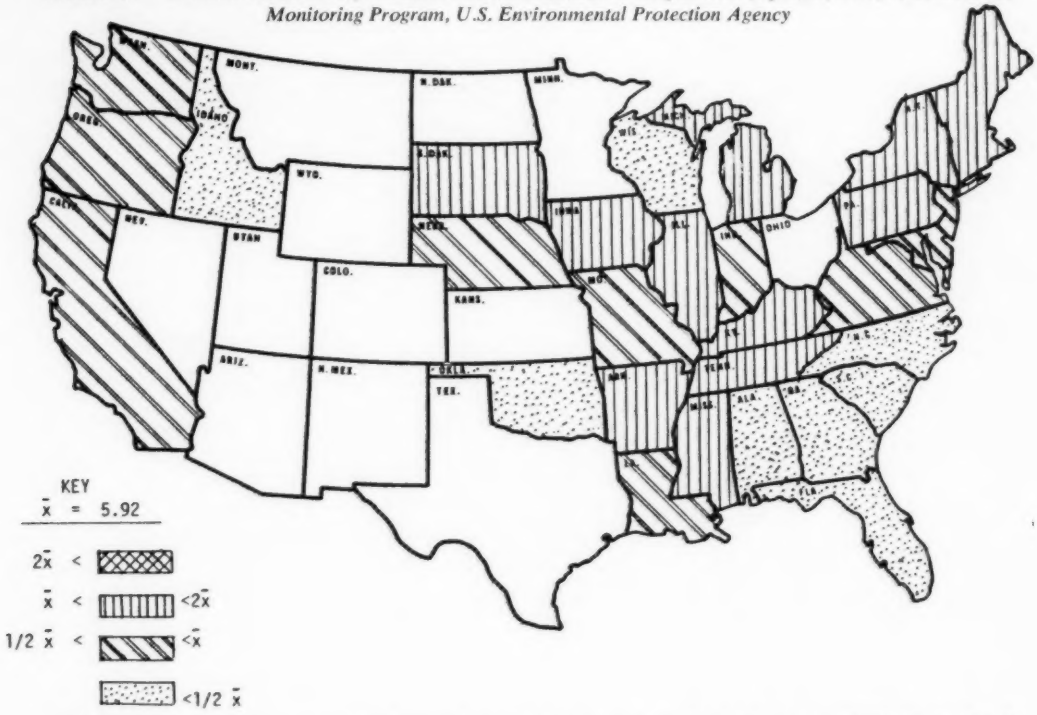

FIGURE 7. *Percent occurrence of elemental arsenic detections in cropland soil, by state, 1971, National Soils Monitoring Program, U.S. Environmental Protection Agency*

Illinois showed the highest percent occurrence of aldrin, dieldrin, chlordane, and heptachlor epoxide (Fig. 2–4, 6). The compounds are soil insecticides or their degradation products used in corn production. ΣDDT residues were concentrated in the southeastern states and California (Fig. 5). Generally, Oklahoma, Oregon, Pennsylvania, and Wisconsin had pesticide levels below the all-sites average detection frequency.

COMPOUND CONCENTRATIONS IN CROPS

Crop samples were collected from 729 sites, or 48 percent of the scheduled 1,533 sites. Samples were collected only from those sites where crops were mature and/or ready for harvest. All crop samples were analyzed for organochlorines. In addition, samples were analyzed for organophosphates and atrazine when pesticide application records indicated their use during the current growing season. Thus, the organophosphate and atrazine concentration data could result in higher occurrence frequencies than might occur if all samples had been analyzed.

Table 6 gives the occurrence of pesticide residues in the crop materials sampled. For all crops, 42 percent of the samples analyzed contained detectable concentrations of organochlorines, 13 percent contained detectable concentrations of organophosphates, and only 1 percent contained detectable concentrations of atrazine. In general, crops with known patterns of heavy pesticide application, or animal feed crops (alfalfa, hay, field corn, soybeans) grown in rotation with these crops, had the highest frequencies of detectable pesticides.

Table 7 presents the compound concentrations detected in each crop sampled. ΣDDT occurred most frequently in all crops analyzed, with the exception of cornstalks, in which dieldrin residues predominated. The high frequency of occurrence of ΣDDT is probably the result of prior, widespread use of DDT.

Acknowledgments

It is not possible to list by name all persons who contributed to this study. The authors are especially grateful to the staff of the Pesticides Monitoring Laboratory, Bay St. Louis, Mississippi, who received, processed and analyzed the samples for compound residues, and to the inspectors of the Animal and Plant Health Inspection Service, USDA, who collected the samples.

TABLE 6. *Occurrence of pesticide residues in standing agricultural crops, 1971—National Soils Monitoring Program*

	Organochlorines			Organophosphates			Triazines		
Crop	No. of Analyses	No. of Positive Detections	% of Positive Detections	No. of Analyses	No. of Positive Detections	% of Positive Detections	No. of Analyses	No. of Positive Detections	% of Positive Detections
Alfalfa/bur clover	61	33	54	17	2	12	—	—	—
Beans, dry	5	0	0	4	0	0	—	—	—
Clover	4	2	50	1	0	0	—	—	—
Corn, field (kernels)	304	40	13	46	1	2	1	1	100
Cornstalks	286	164	57	125	1	1	73	0	0
Cotton	28	15	54	26	8	31	—	—	—
Cottonseed	19	12	63	18	5	28	—	—	—
Cotton stalks	44	40	91	35	27	77	—	—	—
Cowpeas	1	0	0	—	—	—	—	—	—
Grass hay	11	6	55	3	0	0	—	—	—
Milo	2	1	50	—	—	—	—	—	—
Mint	1	1	100	—	—	—	—	—	—
Mixed hay	51	26	51	17	1	6	—	—	—
Oats	1	0	0	—	—	—	—	—	—
Oats, straw	4	4	100	2	0	0	—	—	—
Pasture	18	10	56	3	0	0	—	—	—
Peanuts	8	2	25	1	0	0	—	—	—
Pecans	1	0	0	—	—	—	—	—	—
Rice	2	2	100	—	—	—	—	—	—
Rice straw	1	1	100	—	—	—	—	—	—
Sorghum (grain)	18	6	33	3	0	0	2	0	0
Sorghum stalks	23	14	61	4	0	0	2	0	0
Soybeans	177	69	39	45	0	0	9	0	0
Soybean hay	8	8	100	—	—	—	—	—	—
Sweet sorghum	1	0	0	—	—	—	—	—	—
Timothy	1	0	0	—	—	—	—	—	—
Tobacco	2	2	100	—	—	—	—	—	—
Wheat	1	0	0	—	—	—	—	—	—
Wheat straw	1	0	0	—	—	—	—	—	—
TOTAL	1,084	458	42	350	45	13	87	1	1

TABLE 7. *Compound concentrations in standing agricultural crops, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean	Estimated Geometric Mean[1]	Detected Values Min.	Max.
ALFALFA/BUR CLOVER						
Organochlorines, 61 samples						
Chlordane	2	3.3	0.01	0.001	0.17	0.42
p,p'-DDE	20	32.8	0.01	0.005	0.01	0.09
o,p'-DDT	15	24.6	0.01	0.004	0.01	0.14
p,p'-DDT	27	44.3	0.04	0.014	0.01	0.66
p,p'-TDE	1	1.6	<0.01	—	0.01	—
ΣDDT	28	45.9	0.06	0.018	0.01	0.88
Dieldrin	11	18.0	<0.01	0.002	0.01	0.05
Toxaphene	1	1.6	0.01	—	0.38	—
Organophosphates, 17 samples						
Parathion, ethyl	2	11.8	2.32	0.013	3.20	36.20
Parathion, methyl	1	5.9	0.27	—	4.57	—
BEANS, DRY (All Varieties)						
Organochlorines, 5 samples: no residues detected						
Organophosphates, 4 samples: no residues detected						
CLOVER (*Trifolium* sp.)						
Organochlorines, 4 samples						
p,p'-DDT	1	25.0	<0.01	—	0.02	—
ΣDDT	1	25.0	<0.01	—	0.02	—
Dieldrin	1	25.0	<0.01	—	0.01	—
Organophosphates, 1 sample: no residues detected						
FIELD CORN (Kernels)						
Organochlorines, 304 samples						
Chlordane	3	1.0	<0.01	<0.001	0.08	0.48
p,p'-DDE	2	0.7	<0.01	<0.001	0.01	0.03
o,p'-DDT	1	0.3	<0.01	—	0.05	—
p,p'-DDT	2	0.7	<0.01	<0.001	0.01	0.26
ΣDDT	3	1.0	<0.01	<0.001	0.01	0.34
Dieldrin	38	12.5	<0.01	0.001	0.01	0.07
Heptachlor	1	0.3	<0.01	—	0.05	—
Heptachlor epoxide	1	0.3	<0.01	—	0.01	—
Organophosphates, 46 samples						
Parathion, methyl	1	2.2	<0.01	—	0.09	—
Triazines, 99 samples						
Atrazine	1	1.0	<0.01	—	0.01	—
CORNSTALKS						
Organochlorines, 286 samples						
Chlordane	16	5.6	0.02	0.002	0.05	1.26
p,p'-DDE	37	12.9	<0.01	0.001	0.01	0.06
o,p'-DDT	49	17.1	<0.01	0.002	0.01	0.16
p,p'-DDT	105	36.7	0.02	0.006	0.01	0.55
p,p'-TDE	17	5.9	<0.01	0.001	0.01	0.10
ΣDDT	107	37.1	0.03	0.008	0.01	0.78
Dieldrin	114	39.9	0.01	0.006	0.01	0.17
Endrin	1	0.4	<0.01	—	0.06	—
Heptachlor	3	1.1	<0.01	<0.001	0.01	0.03
Heptachlor epoxide	22	7.7	<0.01	0.001	0.01	0.51
Toxaphene	15	5.3	0.04	0.002	0.07	2.83
Organophosphates, 125 samples						
Parathion, ethyl	1	0.8	<0.01	—	0.36	—
Triazines, 73 samples: no residues detected						
COTTON						
Organochlorines, 28 samples						
p,p'-DDE	7	25.0	0.07	0.006	0.01	1.86
o,p'-DDT	2	7.1	0.25	0.004	0.21	6.87
p,p'-DDT	15	53.6	0.95	0.039	0.01	22.99
ΣDDT	15	53.6	1.27	0.043	0.03	31.72
Dieldrin	1	3.6	<0.01	—	0.02	—
Endrin	1	3.6	<0.01	—	0.09	—
Endrin ketone	1	3.6	<0.01	—	0.06	—
Toxaphene	6	21.4	1.22	0.019	0.18	28.89
Organophosphates, 26 samples						
DEF	6	23.1	0.08	0.012	0.08	0.62
Parathion, ethyl	2	7.7	0.04	0.004	0.49	0.53
Parathion, methyl	1	3.8	0.01	—	0.18	—
COTTONSEED						
Organochlorines, 19 samples						
p,p'-DDE	7	36.8	0.06	0.010	0.01	0.82
o,p'-DDT	6	31.6	0.28	0.019	0.02	3.32

(*Continued next page*)

TABLE 7 (cont'd.). *Compound concentrations in standing agricultural crops, 1971—National Soils Monitoring Program*

Compound	No. of Positive Positive	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean	Estimated Geometric Mean[1]	Detected Values Min.	Max.
p,p'-DDT	9	47.4	0.87	0.040	0.03	14.09
ΣDDT	9	47.4	1.21	0.053	0.04	18.23
Toxaphene	5	26.3	1.12	0.031	0.55	13.54
Organophosphates, 18 samples						
DEF	5	27.8	0.07	0.013	0.10	0.63
COTTON STALKS						
Organochlorines, 44 samples						
Chlordane	1	2.3	0.01	—	0.40	—
o,p'-DDE	1	2.3	<0.01	—	0.10	—
p,p'-DDE	34	77.3	0.30	0.062	0.01	4.06
o,p'-DDT	34	77.3	1.48	0.153	0.01	28.10
p,p'-DDT	40	90.9	7.67	0.691	0.02	114.63
p,p'-TDE	17	38.6	0.83	0.032	0.01	17.78
ΣDDT	40	90.9	9.15	0.916	0.04	160.51
Dieldrin	4	8.9	<0.01	0.001	0.01	0.08
Endrin	1	2.3	0.14	—	6.26	—
Endrin ketone	1	2.3	0.01	—	0.37	—
Heptachlor epoxide	1	2.3	<0.01	—	0.01	—
Toxaphene	31	70.5	10.21	0.628	0.15	150.00
Organophosphates, 35 samples						
DEF	17	48.6	2.01	0.085	0.11	37.13
Parathion, ethyl	5	14.3	0.23	0.006	0.04	7.32
Parathion, methyl	21	60.0	0.30	0.068	0.04	1.53
COWPEAS						
Organochlorines, 1 sample: no residues detected						
GRASS HAY						
Organochlorines, 11 samples						
Chlordane	1	9.1	0.01	—	0.19	—
p,p'-DDE	5	45.4	0.02	0.007	0.01	0.12
o,p'-DDT	4	36.4	0.03	0.008	0.01	0.32
p,p'-DDT	5	45.4	0.08	0.015	0.02	0.73
ΣDDT	5	45.4	0.13	0.021	0.03	1.17
Dieldrin	2	18.2	<0.01	0.002	0.01	0.02
Toxaphene	2	18.2	0.21	0.012	0.26	2.00
Organophosphates, 3 samples: no residues detected						
MILO						
Organochlorines, 2 samples						
Dieldrin	1	50.0	0.05	—	0.11	—
MINT						
Organochlorines, 1 sample						
p,p'-DDE	1	100.0	0.05	—	0.05	—
o,p'-DDT	1	100.0	0.01	—	0.01	—
p,p'-DDT	1	100.0	0.15	—	0.15	—
ΣDDT	1	100.0	0.21	—	0.21	—
MIXED HAY						
Organochlorines, 51 samples						
Chlordane	4	7.8	0.07	0.004	0.25	1.68
p,p'-DDE	12	23.5	0.01	0.003	0.01	0.48
o,p'-DDT	8	15.7	0.03	0.003	0.01	1.23
p,p'-DDT	17	33.3	0.26	0.011	0.01	12.24
p,p'-TDE	1	2.0	<0.01	—	0.01	—
ΣDDT	17	33.3	0.31	0.012	0.02	13.95
Dieldrin	15	29.4	0.01	0.004	0.01	0.05
Toxaphene	6	11.8	0.36	0.007	0.16	15.73
Organophosphates, 17 samples						
DEF	1	5.9	<0.01	—	0.06	—
Parathion, methyl	1	5.9	<0.01	—	0.02	—
OATS						
Organochlorines, 1 sample: no residues detected						
OAT HAY/STRAW						
Organochlorines, 4 samples						
Chlordane	1	25.0	0.01	—	0.03	—
p,p'-DDE	2	50.0	<0.01	0.004	0.01	—
o,p'-DDT	2	50.0	<0.01	0.004	0.01	—
p,p'-DDT	3	75.0	0.02	0.019	0.02	0.04
ΣDDT	3	75.0	0.03	0.026	0.04	0.06
Dieldrin	2	50.0	0.01	0.009	0.01	0.05
Organophosphates 2 samples: no residues detected						

(*Continued next page*)

TABLE 7 (cont'd.). *Compound concentrations in standing agricultural crops, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean	Estimated Geometric Mean[1]	Detected Values Min.	Max.
PASTURE						
Organochlorines, 18 samples						
Chlordane	3	16.7	0.05	0.009	0.37	0.63
p,p'-DDE	3	16.7	<0.01	0.001	0.01	0.02
o,p'-DDT	2	11.1	<0.01	0.001	0.02	0.03
p,p'-DDT	6	33.3	0.01	0.005	0.01	0.08
o,p'-TDE	1	5.6	<0.01	—	0.45	—
p,p'-TDE	1	5.6	<0.01	—	0.07	—
ΣDDT	6	33.3	0.04	0.008	0.01	0.63
Dieldrin	6	33.3	<0.01	0.006	0.02	0.05
Endrin	1	5.6	<0.01	—	0.01	—
Heptachlor epoxide	1	5.6	<0.01	—	0.01	—
Toxaphene	1	5.6	0.01	—	0.23	—
Organophosphates, 3 samples: no residues detected						
PEANUTS						
Organochlorines, 8 samples						
Dieldrin	2	25.0	0.01	0.004	0.02	0.03
Organophosphates, 1 sample: no residues detected						
PECANS						
Organochlorines, 1 sample: no residues detected						
RICE						
Organochlorines, 2 samples						
p,p'-DDE	2	100.0	0.02	0.018	0.01	0.03
o,p'-DDT	1	50.0	0.03	—	0.06	—
p,p'-DDT	2	100.0	0.15	0.096	0.03	0.27
ΣDDT	2	100.0	0.20	0.126	0.04	0.36
Heptachlor	1	50.0	<0.01	—	0.01	—
RICE STRAW						
Organochlorines, 1 sample						
p,p'-DDE	1	100.0	0.04	—	0.04	—
o,p'-DDT	1	100.0	0.11	—	0.11	—
p,p'-DDT	1	100.0	0.12	—	0.12	—
ΣDDT	1	100.0	0.27	—	0.27	—
Toxaphene	1	100.0	0.52	—	0.52	—
SORGHUM						
Organochlorines, 18 samples						
Chlordane	3	16.7	0.03	0.005	0.02	0.42
p,p'-DDE	2	11.1	0.01	0.003	0.07	0.14
o,p'-DDT	1	5.6	0.02	—	0.30	—
p,p'-DDT	3	16.7	0.06	0.007	0.02	0.64
p,p'-TDE	1	5.6	<0.01	—	0.05	—
ΣDDT	3	16.7	0.04	—	—	—
Dieldrin	4	22.2	0.02	0.004	0.01	0.28
Endrin	1	5.6	<0.01	—	0.02	—
Heptachlor epoxide	1	5.6	<0.01	—	0.02	—
Toxaphene	1	5.6	0.05	—	0.84	—
Organophosphates, 3 samples: no residues detected						
Triazines, 2 samples: no residues detected						
SORGHUM STALKS						
Organochlorines, 23 samples						
Chlordane	4	17.4	0.08	0.009	0.11	0.81
p,p'-DDE	6	26.1	0.01	0.005	0.01	0.12
o,p'-DDT	10	43.5	0.03	0.008	0.01	0.33
p,p'-DDT	15	65.2	0.09	0.023	0.01	1.07
p,p'-TDE	4	17.4	<0.01	0.002	0.02	0.03
ΣDDT	16	69.6	0.13	0.031	0.01	1.52
Dieldrin	6	26.1	0.05	0.010	0.02	0.51
Endrin	1	4.3	0.03	—	0.60	—
Endrin ketone	1	4.3	0.01	—	0.19	—
Heptachlor	1	4.3	<0.01	—	0.02	—
Heptachlor epoxide	2	8.7	<0.01	0.001	0.03	0.04
Toxaphene	4	17.4	0.09	0.009	0.24	0.91
Organophosphates, 4 samples: no residues detected						
Triazines, 2 samples: no residues detected						
SWEET SORGHUM						
Organochlorines, 1 sample: no residues detected						

(*Continued next page*)

TABLE 7 (cont'd.). *Compound concentrations in standing agricultural crops, 1971—National Soils Monitoring Program*

Compound	No. of Positive Detections	% of Positive Detections	Residues, ppm Dry Weight			
			Arithmetic Mean	Estimated Geometric Mean[1]	Detected Values Min.	Max.
SOYBEANS						
Organochlorines, 177 samples						
p,p'-DDE	5	2.8	<0.01	<0.001	0.01	0.02
o,p'-DDT	1	0.6	<0.01	—	0.01	—
p,p'-DDT	4	2.3	<0.01	<0.001	0.01	0.05
ΣDDT	5	2.8	<0.01	<0.001	0.02	0.07
Dieldrin	55	31.1	<0.01	0.003	0.01	0.05
Endrin	7	3.9	<0.01	<0.001	0.01	0.03
Heptachlor epoxide	2	1.1	<0.01	<0.001	0.01	0.03
Toxaphene	3	1.7	0.01	0.001	0.10	0.66
Organophosphates, 45 samples: no residues detected						
Triazines, 9 samples: no residues detected						
SOYBEAN HAY						
Organochlorines, 8 samples						
Chlordane	1	12.5	0.02	—	0.17	—
p,p'-DDE	4	50.0	0.01	0.006	0.01	0.02
o,p'-DDT	2	25.0	<0.01	0.002	0.01	—
p,p'-DDT	6	75.0	0.02	0.017	0.01	0.05
p,p'-TDE	3	37.5	0.01	0.005	0.01	0.04
ΣDDT	6	75.0	0.04	0.027	0.01	0.09
Dieldrin	5	62.5	0.01	0.006	0.01	0.02
Endrin	1	12.5	<0.01	—	0.01	—
TIMOTHY						
Organochlorines, 1 sample: no residues detected						
TOBACCO						
Organochlorines, 2 samples						
o,p'-DDE	1	50.0	0.25	—	0.50	—
p,p'-DDE	1	50.0	0.39	—	0.78	—
o,p'-DDT	1	50.0	1.10	—	2.20	—
p,p'-DDT	2	100.0	3.87	0.384	0.01	7.74
o,p'-TDE	1	50.0	2.87	—	5.74	—
p,p'-TDE	1	50.0	8.54	—	17.09	—
ΣDDT	2	100.0	17.03	0.815	0.01	34.05
Dieldrin	1	50.0	0.34	—	0.69	—
Endosulfan	1	50.0	0.66	—	1.33	—
Endosulfan II	1	50.0	2.63	—	5.26	—
Endosulfan sulfate	1	50.0	3.28	—	6.57	—
WHEAT						
Organochlorines, 1 sample: no residues detected						
WHEAT STRAW						
Organochlorines, 1 sample: no residues detected						

[1] Not calculated when fewer than two positive detections were present.

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Pesticide Application and Cropping Data from 37 States, 1971— National Soils Monitoring Program

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ABSTRACT

This report summarizes pesticide application and cropping data collected in 1971 from 1,473 agricultural sampling sites in 37 states as part of the National Soils Monitoring Program. Pesticide application data are summarized by all sites, state, and crop. Tables generally give the number of reporting sites, the number of times a compound was applied, the percent occurrence, and the arithmetic mean total application rate.

Pesticides applied most frequently to sampling sites were atrazine, 2,4-D, captan, and malathion. Pesticides were most frequently applied to field corn and cotton, least frequently to alfalfa/bur clover and mixed hay.

Introduction

In 1963, the report of the President's Science Advisory Committee recommended that appropriate federal agencies "develop a continuing network to monitor residue levels in air, water, soil, man, wildlife and fish" (*1*). As a result of this recommendation, the National Pesticide Monitoring Program (NPMP) was established to determine levels and trends of pesticides and their degradation products in the environment (*3*). Federal responsibility for monitoring pesticides was officially mandated in Section 20 of the amended Federal Insecticide, Fungicide and Rodenticide Act of 1972 (PL 92–516).

The National Soils Monitoring Program is an integral part of the NPMP, monitoring agricultural soils and raw agricultural crops. It was initiated in 1968 by the U.S. Department of Agriculture and is administered by the U.S. Environmental Protection Agency. The present report summarizes pesticide application and cropping data collected in 1971 from 1,473 sampling sites in 37 states. Composite soil and crop samples were also collected from these sites for pesticide residue analyses, the results of which are published separately (*2*).

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Sampling

The site selection criteria and statistical design of the National Soils Monitoring Program have been described (*4*). In 1971, 1,533 sites in 37 states were scheduled for sampling (Fig. 1). At each 4-hectare (10-acre) site, landowners or operators supplied information on the crops grown and the kinds and amounts of pesticides applied during 1971.

Results and Discussion

COMPOUNDS APPLIED TO CROPLAND

Pesticide use data were received from 1,473 or 96 percent of the scheduled 1,533 sites. Of these, 784 or 53 percent of the sites had one or more pesticides applied during 1972. Tables summarizing the application data show the number and percent of sites with reported pesticide application and the average rate of total pesticide application for each site, expressed both in pounds per acre and kilograms per hectare.

Table 1 gives the frequency of pesticide use on sample sites in various states and state groups. Because some of the smaller eastern states had very few sites, those with similar geographic location and/or agricultural characteristics were combined to obtain more representative data. States were grouped as follows: Mid-Atlantic: Delaware, Maryland, New Jersey; New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; and Virginia and West Virginia. Among the individual states and state groups, frequency of pesticide use ranged from 23 percent in Pennsylvania to 77 percent in Mississippi.

ALL SITES

Applications of 132 compounds were recorded for all reporting sites. The compounds included 50 herbicides, including defoliants, 48 insecticides and/or acaricides, 28 fungicides, 4 nematocides, 1 soil fumigant, and 1 growth retardant (Table 2). The most frequently applied compounds were atrazine, 2,4-D, captan, and malathion, which were reported from 14, 10, 9, and 8 percent of the reporting sites, respectively.

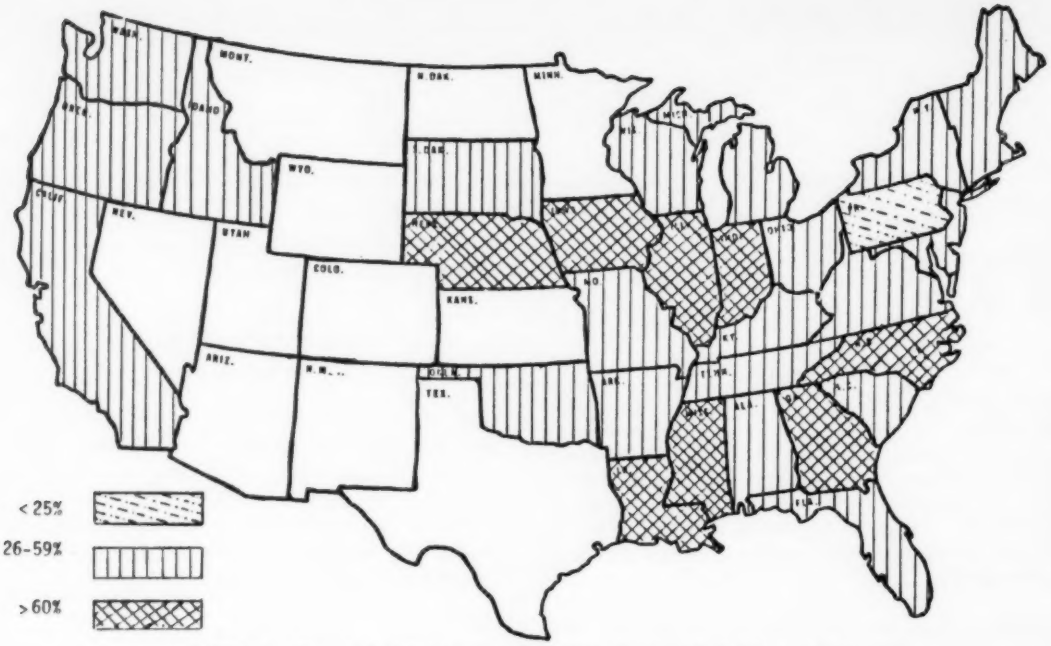

FIGURE 1. *States scheduled for sampling, 1971, National Soils Monitoring Program*

TABLE 1. *Occurrence of pesticide applications by state, 1971—National Soils Monitoring Program*

State or State Group[1]	Total No. of Sites Reporting	Pesticides Applied		Pesticides Not Applied	
		No. of Sites	%	No. of Sites	%
Alabama	22	9	41	13	59
Arkansas	45	24	53	21	47
California	61	29	48	32	52
Florida	18	8	44	10	56
Georgia	29	19	66	10	34
Idaho	33	11	33	22	67
Illinois	142	100	70	42	30
Indiana	74	50	68	24	32
Iowa	152	103	68	49	32
Kentucky	28	11	39	17	61
Louisiana	25	17	68	8	32
Michigan	54	25	46	29	54
Mid-Atlantic	16	7	44	9	56
Mississippi	31	24	77	7	23
Missouri	79	37	46	42	54
Nebraska	106	65	61	41	39
New England	21	6	29	15	71
New York	36	17	47	19	53
N. Carolina	30	18	60	12	40
Ohio	57	31	54	26	46
Oklahoma	60	22	37	38	63
Oregon	37	13	35	24	65
Pennsylvania	35	8	23	27	77
S. Carolina	15	8	53	7	47
S. Dakota	106	51	48	55	52
Tennessee	24	11	46	13	54
Virginia and W. Virginia	25	8	32	17	68
Washington state	45	22	49	23	51
Wisconsin	67	30	45	37	55
Total	1473	784	53	689	47

[1] Some smaller eastern states which had few sites but similar geographic locations and/or agricultural characteristics were combined to obtain more representative data, including: Mid-Atlantic states: Delaware, Maryland, New Jersey; New England states: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; and Virginia and West Virginia.

BY STATE

Table 3 presents the application data by state or state grouping. Because of the number of states sampled, it is not feasible to discuss in detail the pesticide data from each state. However, the pesticide application information from each state reflects both the crops grown and the intensity of agricultural land use in the state.

In Figure 2, the frequency of reported pesticide applications in each state is designated as follows: low, states where less than 25 percent of the sites reported pesticide applications; medium, states where 25–59 percent of the sites reported applications; and, high, where over 60 percent of the sites in a state reported pesticide applications.

BY CROP

Table 4 lists crops grown on sample sites in 1972 as well as the pesticide application status for each crop. Application data for selected major crops are presented in Table 5. Pesticide use varied widely among these crops.

Table 6 shows the pesticide applications in 1971 for selected major crops, by state.

Acknowledgment

It is not possible to list by name all the persons who contributed to this study. However, the authors are especially grateful to the inspectors from the Plant Protection and Quarantine Programs, Animal and Plant Health Inspection Service, U.S. Department of Agriculture, who collected the data.

TABLE 2. *Compounds applied to 1,473 cropland sites, 1971—National Soils Monitoring Program*

Compound	Trade Name, If Noted	Pesticides Applied		Average Total Application	
		No. of Sites	% of Sites	lb./Acre	kg/Hectare
Alachlor	Lasso	65	4.4	1.58	1.77
Aldrin		45	3.0	1.15	1.29
Arsenic pentoxide		2	0.1	0.50	0.56
Atrazine	AAtrex	214	14.1	1.78	1.99
Azinphosmethyl	Guthion	6	0.4	0.60	0.67
Bacillus thuringiensis	B.T.	1	0.1	0.11	0.12
Barban	Carbyne	1	0.1	0.25	0.28
Benefin	Balan	3	0.2	1.11	1.24
BHC		3	0.2	0.02	0.02
Bordeaux mixture		1	0.1	1.25	1.40
Bromacil	Hyvar	3	0.2	0.62	0.70
Butylate	Sutan	18	1.2	1.74	1.95
Bux		17	1.1	1.26	1.41
Captafol	Difolatan	1	0.1	1.50	1.68
Captan		138	9.3	0.11	0.12
Carbaryl	Sevin	18	1.2	2.12	2.37
Carbophenothion	Trithion	1	0.1	3.20	3.58
Carbofuran	Furadan	20	1.3	1.01	1.13
Chevron RE-5353		4	0.3	0.85	0.95
Chloramben	Amiben	41	2.8	1.39	1.56
Chlordane		1	0.1	2.50	2.80
Chlorobenzilate	Acaraben	2	0.1	1.38	1.55
Chloroneb	Demosan	9	0.6	0.02	0.02
Chloropropham	Chloro-IPC	1	0.1	2.50	2.80
Chlorothalonil	Bravo	1	0.1	3.00	3.36
Copper carbonate (basic)		1	0.1	3.90	4.37
Copper hydroxide		1	0.1	1.08	1.21
Copper oxide		1	0.1	1.70	1.90
Copper sulfate		3	0.2	13.97	15.65
Cypromid	Clobber	1	0.1	0.75	0.84
2,4-D	Decamine	145	9.8	0.87	0.97
Dalapon	Dowpon	4	0.3	2.60	2.91
2,4-DB	Butyrac	7	0.5	0.64	0.72
DCPA	Dacthal	1	0.1	3.75	4.20
DDT		33	2.2	3.83	4.29
DEF		9	0.6	1.03	1.16
Demeton	Systox	2	0.1	1.56	1.75
Diallate	Avadex	1	0.1	0.12	0.13
Diazinon		15	1.0	0.75	0.84
Dicamba	Banvel D	12	0.8	0.31	0.34
Dichlofenthion	Nemacide	1	0.1	6.00	6.72
Dichloropropene	Telone	3	0.2	28.00	31.36
Dichlorprop	2,4-DP	1	0.1	3.00	3.36
Dicofol	Kelthane	1	0.1	1.00	1.12
Dieldrin		6	0.4	0.09	0.10
Dinitrocresol		3	0.2	1.64	1.84
Diphenamid	Enide	1	0.1	0.25	0.28
Disulfoton	Di-Syston	24	1.6	1.21	1.35
Diuron	Karmex	9	0.6	1.56	1.75
DNBP	Premerge	16	1.1	1.35	1.51
Dodine		2	0.1	0.83	0.93
DSMA		11	0.7	2.00	2.24
Dyfonate		1	0.1	0.90	1.00
EMTS	Ceresan M	9	0.6	0.06	0.06
Endosulfan	Thiodan	8	0.5	1.44	1.61
Endrin		3	0.2	2.20	2.46
EPTC	Eptam	10	0.7	2.09	2.34
Ethoprop	Mocap	1	0.1	1.00	1.12
Ethylmercury chloride	Ceresan Red	8	0.5	0.03	0.03
Fensulfothion	Dasanit	5	0.3	1.15	1.28
Fentin hydroxide		1	0.1	2.25	2.52
Ferbam		2	0.1	2.59	2.90
Fluometuron	Cotoran	22	1.5	0.95	1.06
Folex		5	0.3	1.05	1.18
Folpet	Phaltan	1	0.1	1.00	1.12
Furethrin		1	0.1	8.00	8.97
Heptachlor		8	0.5	1.27	1.42
Hexachlorobenzene	HCB	7	0.5	0.01	0.01
Isodrin		1	0.1	0.01	0.01
Lead arsenate		3	0.2	7.07	7.91
Lindane		1	0.1	0.02	0.02
Linuron	Lorox	23	1.6	0.89	1.00
Londax		1	0.1	0.50	0.56
Malathion		111	7.5	0.16	0.18
Maleic hydrazide	MH	3	0.2	3.00	3.36
Mancozeb	Dithane M-45	2	0.1	12.40	13.89
Maneb		3	0.2	2.34	2.62
MCPA	MCP	5	0.3	0.70	0.78
Mercury		2	0.1	0.06	0.06
Metham	Vapam	1	0.1	2.16	2.42
Methomyl	Lannate	1	0.1	1.13	1.27
Methoxychlor		24	1.6	0.17	0.19
Methylmercury acetate	Ceresan L	6	0.4	0.01	0.01
Methylmercury dicyandiamide	Panogen	18	1.2	0.08	0.09
Methyl trithion		1	0.1	3.00	3.36
Mevinphos	Phosdrin	2	0.1	0.75	0.84
Mirex		6	0.4	0.07	0.08
Monocrotophos	Azodrin	4	0.3	0.33	0.36
Monuron	Telvar	2	0.1	1.30	1.46
MSMA		17	1.1	1.77	1.99
Nabam		1	0.1	5.00	5.60
Naptalam	Alanap	4	0.3	1.94	2.17
Nitralin	Planavin	5	0.3	1.05	1.18
Oil Spray		2	0.1	60.00	67.20
Ovex		1	0.1	0.50	0.56
Oxydemeton-methyl	Metasystox-R	2	0.1	0.50	0.56
Paraquat		4	0.3	0.86	0.97
Parathion, ethyl		21	1.4	3.32	3.72
Parathion, methyl		48	3.2	2.81	3.15
PCNB		2	0.1	3.51	3.93
Pebulate	Tillam	1	0.1	0.12	0.13
Pentachlorophenol	PCP	2	0.1	3.02	3.38
Phenylmercury actate	PMA	2	0.1	0.01	0.01
Phenylmercury urea		3	0.2	0.01	0.01
Phorate	Thimet	21	1.4	1.71	1.91
Phosalone	Zolone	1	0.1	4.00	4.48
Phosphamidon	Dimecron	2	0.1	0.27	0.30
Prolate	Imidan	2	0.1	11.60	13.00
Prometryn	Caparol	2	0.1	1.08	1.21
Propachlor	Ramrod	44	3.0	1.64	1.83
Propanil	Stam	6	0.4	3.46	3.87
Propargite	Omite	2	0.1	2.58	2.88
Pyrazon	Pyramin	1	0.1	1.25	1.40
Silvex		3	0.2	0.42	0.47
Simazine	Princep	9	0.6	4.00	4.48
Sodium chlorate		5	0.3	1.74	1.95
Solan		1	0.1	1.00	1.12
Sulfur		12	0.8	34.27	38.38
2,4,5-T		2	0.1	0.30	0.34
TCA		2	0.1	2.50	2.80
TEPP		1	0.1	4.00	4.48
Terbacil	Sinbar	1	0.1	1.40	1.56
Terbutryn	Igran	1	0.1	1.75	1.96
Terrazole		1	0.1	0.15	0.16
Tetradifon	Tedion V-18	1	0.1	0.75	0.84
Thiram		13	0.9	0.01	0.01
Toxaphene		33	2.2	7.00	7.84
Trichlorfon	Dylox	2	0.1	0.88	0.98
Trietazine		1	0.1	0.70	0.78
Trifluralin	Treflan	64	4.3	0.95	1.06
Vernolate	Vernam	2	0.1	2.25	2.52
Zineb		1	0.1	7.50	8.40

TABLE 3. *Compounds applied to cropland sites by state, 1971—National Soils Monitoring Program*

Compound	Trade Name, If Noted	Pesticides Applied: No. of Sites	Pesticides Applied: % of Sites	Average Total Application: lb./Acre	Average Total Application: kg/Hectare
ALABAMA, 22 SITES					
Atrazine	AAtrex	3	13.6	2.67	2.98
Benefin	Balan	1	4.5	0.75	0.84
Butylate	Sutan	2	9.0	0.25	0.28
DDT		3	13.6	3.67	4.10
Disulfoton	Di-Syston	1	4.5	7.00	7.84
Diuron	Karmex	1	4.5	0.34	0.38
DSMA		1	4.5	1.50	1.68
EMTS	Ceresan M	1	4.5	0.01	0.01
Endrin		1	4.5	1.40	1.56
Fluometuron	Cotoran	3	13.6	0.92	1.02
MSMA		1	4.5	2.00	2.24
Parathion, ethyl		1	4.5	1.40	1.56
Parathion, methyl		3	13.6	2.23	2.50
PCNB		1	4.5	7.00	7.84
Toxaphene		3	13.6	4.55	5.09
Trifluralin	Treflan	1	4.5	0.50	0.56
ARKANSAS, 45 SITES					
Aldrin		1	2.2	0.75	0.84
Atrazine	AAtrex	1	2.2	0.75	0.84
Captan		1	2.2	0.01	0.01
Chloroneb	Demosan	2	4.4	0.01	0.01
2,4-D		1	2.2	0.50	0.56
2,4-DB		1	2.2	1.50	1.68
DDT		3	6.6	0.57	0.63
Disulfoton	Di-Syston	1	2.2	0.25	0.28
DNBP	Premerge	5	11.1	0.94	1.05
DSMA		2	4.4	1.20	1.34
EMTS	Ceresan M	3	6.6	0.15	0.16
Fluometuron	Cotoran	5	11.1	0.84	0.92
Linuron	Lorox	2	4.4	0.50	0.56
Methylmercury dicyandiamide	Panogen	3	6.6	0.25	0.28
Monuron	Telvar	1	2.2	1.00	1.12
MSMA		5	11.1	1.20	1.34
Nitralin	Planavin	3	6.6	1.17	1.30
Parathion, ethyl		1	2.2	7.00	7.84
Parathion, methyl		5	11.1	2.00	2.24
Propanil	Stam	2	4.4	5.50	6.16
Solan		1	2.2	1.00	1.12
Thiram		1	2.2	0.01	0.01
Toxaphene		3	6.6	1.00	1.12
Trifluralin	Treflan	9	20.0	1.11	1.24
CALIFORNIA, 61 SITES					
Aldrin		1	1.6	0.01	0.01
Azodrin		1	1.6	0.50	0.56
Bacillus thuringiensis		1	1.6	0.11	0.12
Captan		1	1.6	0.01	0.01
2,4-D		2	3.2	0.31	0.34
DCPA	Dacthal	1	1.6	3.75	4.20
Diazinon		2	3.2	0.08	0.08
Dicofol	Kelthane	1	1.6	1.00	1.12
Diphenamid	Enide	1	1.6	0.25	0.28
Diuron	Karmex	1	1.6	2.40	2.68
EPTC	Eptam	1	1.6	3.00	3.36
Ethylmercury chloride	Ceresan Red	1	1.6	0.01	0.01
Malathion		4	6.5	1.71	1.91
MCPA	MCP	2	3.2	1.25	1.40
Mercury		2	3.2	0.06	0.06
Methomyl	Lannate	1	1.6	1.13	1.26
Mevinphos	Phosdrin	1	1.6	1.00	1.12
Oil Spray		1	1.6	50.00	56.04
Ovex		1	1.6	0.50	0.56
Oxydemeton-methyl	Metasystox-R	1	1.6	0.50	0.56
Paraquat		2	3.2	0.22	0.25
Parathion, ethyl		4	6.5	2.08	2.32
Parathion, methyl		2	3.2	1.38	1.54
PCNB		1	1.6	0.01	0.01
Pebulate	Tillam	1	1.6	0.12	0.13
Phenylmercury acetate	PMA	1	1.6	0.01	0.01
Propargite	Omite	1	1.6	0.15	0.16
Simazine	Princep	3	4.9	8.00	8.96
Sodium chlorate		1	1.6	5.00	5.60
Sulfur		5	8.1	15.34	17.19
Tetradifon	Tedion V-18	1	1.6	0.75	0.84
Toxaphene		1	1.6	0.40	0.44
Trichlorfon	Dylox	2	3.2	0.88	0.98
Trifluralin	Treflan	2	3.2	0.20	0.22
FLORIDA, 18 SITES					
Atrazine	AAtrex	2	11.1	2.75	3.08
Carbaryl	Sevin	1	5.5	5.00	5.60
Carbofuran	Furadan	1	5.5	4.00	4.48
Chlorobenzilate	Acaraben	2	11.1	1.38	1.54
Copper carbonate (basic)		1	5.5	3.90	4.37
2,4-D		3	16.6	5.33	5.97
Dalapon	Dowpon	1	5.5	1.50	1.68
Endrin		1	5.5	1.00	1.12
EPTC	Eptam	1	5.5	0.20	0.22
Malathion		1	5.5	3.17	3.55
Maneb		1	5.5	0.08	0.08
Oil Spray		1	5.5	70.00	78.45
Sulfur		3	16.6	78.67	88.16
Zineb		1	5.5	7.50	8.40
GEORGIA, 30 SITES					
Benefin	Balan	1	3.3	1.50	1.68
Butylate	Sutan	1	3.3	0.75	0.84
Captan		5	16.6	0.02	0.02
Carbaryl	Sevin	2	6.6	2.56	2.86
Chlorothalonil	Bravo	1	3.3	3.00	3.36
Copper oxide		1	3.3	1.70	1.90
Copper sulfate		1	3.3	30.00	33.62
2,4-D		2	6.6	0.75	0.84
DDT		5	16.6	2.61	2.93
DNBP		2	6.6	1.50	1.68
Ethylmercury chloride	Ceresan Red	2	6.6	0.01	0.01
Folex		1	3.3	1.50	1.68
Malathion		2	6.6	0.01	0.01
Maleic hydrazide		1	3.3	3.00	3.36
Methoxychlor		2	6.6	0.02	0.02
Methyl trithion		1	3.3	3.00	3.36
Mirex		2	6.6	0.04	0.04
Parathion, ethyl		3	10.0	7.88	9.52
Parathion, methyl		5	16.6	3.45	3.86
Sulfur		2	6.6	25.00	28.02
Thiram		3	10.0	0.01	0.01
Toxaphene		4	13.3	4.00	4.48
Trifluralin	Treflan	5	16.6	0.39	0.44
Vernolate	Vernam	1	3.3	2.50	2.80
IDAHO, 33 SITES					
Captan		1	3.0	0.08	0.08
2,4-D		3	9.0	0.67	0.75
DDT		2	6.0	3.25	3.64
Diallate	Avadex	1	3.0	0.12	0.13
Ethylmercury chloride	Ceresan Red	2	6.0	0.10	0.11
Malathion		1	3.0	1.00	1.12
PCP		1	3.0	0.03	0.03
Trifluralin	Treflan	1	3.0	1.00	1.12
ILLINOIS, 142 SITES					
Alachlor	Lasso	15	10.5	1.93	2.16
Aldrin		13	9.1	1.15	1.29
Atrazine	AAtrex	22	15.4	1.74	1.95
Butylate	Sutan	3	2.1	1.47	1.64
Bux		2	1.4	1.40	1.56
Captan		59	41.5	0.01	0.01
Carbofuran	Furadan	2	1.4	0.33	0.36
Chloramben	Amiben	18	12.6	1.47	1.64
2,4-D		6	4.2	1.11	1.24
Demeton	Systox	1	0.7	0.12	0.13
Fensulfothion	Dasanit	1	0.7	0.90	1.00
Ferbam		1	0.7	2.00	2.24

(Continued next page)

TABLE 3 (cont'd.). *Compounds applied to cropland sites by state, 1971—National Soils Monitoring Program*

Compound	Trade Name, If Noted	Pesticides Applied		Average Total Application	
		No. of Sites	% of Sites	lb./Acre	kg/Hectare
Heptachlor		4	2.8	1.75	1.96
Linuron	Lorox	6	4.2	0.89	0.99
Malathion		52	36.6	0.01	0.01
Methoxychlor		15	10.5	0.01	0.01
MSMA		1	0.7	0.25	0.28
Paraquat		1	0.7	2.00	2.24
PCP		1	0.7	6.00	6.72
Phorate	Thimet	7	4.9	0.62	0.69
Propachlor	Ramrod	18	12.6	1.22	1.36
Simazine	Princep	1	0.7	2.00	2.24
Trifluralin	Treflan	8	5.6	1.20	1.34
2,4,5-T		1	0.7	0.25	0.28
INDIANA, 76 SITES					
Alachlor	Lasso	9	11.8	1.56	1.74
Aldrin		9	11.8	1.35	1.51
Atrazine	AAtrex	20	26.3	1.92	2.15
Azinphosmethyl	Guthion	1	1.3	0.22	0.24
Butylate	Sutan	1	1.3	1.00	1.12
Chloramben	Amiben	7	9.2	1.44	1.61
Captan		1	1.3	0.01	0.01
Carbaryl	Sevin	1	1.3	0.61	0.68
Chlordane		1	1.3	2.50	2.80
Copper hydroxide		1	1.3	1.08	1.21
Copper sulfate		1	1.3	1.42	1.59
2,4-D		4	5.2	0.63	0.70
Diazinon		1	1.3	0.40	0.44
DNBP	Premerge	1	1.3	2.25	2.52
Endosulfan		1	1.3	0.54	0.60
EPTC	Eptam	1	1.3	2.00	2.24
Linuron	Lorox	2	2.6	0.55	0.61
Maneb		1	1.3	2.14	2.39
Propachlor	Ramrod	2	2.6	1.20	1.34
Silvex		1	1.3	0.25	0.28
Simazine	Princep	3	3.9	2.00	2.24
Trifluralin	Treflan	5	6.5	2.37	2.66
2,4,5-T		1	1.3	0.35	0.39
IOWA, 152 SITES					
Alachlor	Lasso	15	9.8	0.93	1.04
Aldrin		10	6.5	0.83	0.93
Atrazine	AAtrex	39	25.6	1.39	1.56
Butylate	Sutan	7	4.6	2.46	2.75
Bux		6	3.9	0.82	0.92
Captan		1	0.6	0.01	0.01
Carbaryl	Sevin	1	0.6	1.60	1.79
Carbofuran	Furadan	7	4.6	0.92	1.03
Chloramben	Amiben	12	7.8	1.10	1.23
2,4-D		19	12.5	0.54	0.61
DDT		2	1.3	1.00	1.12
Diazinon		6	3.9	0.54	0.61
Dicamba	Banvel D	3	1.9	0.75	0.84
DNBP	Premerge	2	1.3	0.44	0.49
Dyfonate		1	0.6	0.90	1.00
Ethoprop	Mocap	1	0.6	1.00	1.12
Fensulfothion		1	0.6	1.02	1.14
Lindane		1	0.6	0.02	0.02
Linuron	Lorox	3	1.9	1.00	1.12
Phorate	Thimet	6	3.9	0.93	1.04
Propachlor	Ramrod	14	8.5	1.50	1.68
Toxaphene		1	0.6	2.73	3.05
Trifluralin	Treflan	14	9.2	0.69	0.77
KENTUCKY, 31 SITES					
Atrazine	AAtrex	2	6.4	1.02	1.14
Dalapon	Dowpon	2	6.4	1.05	1.17
2,4-D		1	3.2	0.05	0.05
2,4-DB	Butyrac	1	3.2	0.80	0.89
Paraquat		1	3.2	1.00	1.12
LOUISIANA, 25 SITES					
Alachlor	Lasso	1	4.0	1.00	1.12
Aldrin		3	12.0	0.15	0.16
Azinphosmethyl	Guthion	1	4.0	0.75	0.84
2,4-D		4	16.0	0.81	0.91
2,4-DB	Butyrac	1	4.0	1.95	2.18
Dalapon	Dowpon	1	4.0	6.80	7.62
DDT		5	20.0	6.62	7.41
DEF		1	4.0	1.12	1.25
Diuron	Karmex	1	4.0	0.70	0.78
DSMA		5	20.0	2.24	2.51
EMTS	Ceresan M	1	4.0	0.01	0.01
Fluometuron	Cotoran	6	24.0	0.99	1.11
Linuron	Lorox	1	4.0	0.50	0.56
Methylmercury dicyandiamide	Panogen	3	12.0	0.08	0.08
Monocrotophos	Azodrin	3	12.0	0.27	0.29
Monuron		1	4.0	1.60	1.79
MSMA		2	8.0	1.46	1.63
Nitralin	Planavin	1	4.0	0.75	0.84
Parathion, methyl		7	28.0	3.56	3.99
Prometryn	Caparol	2	8.0	1.08	1.21
Propanil	Stam	4	16.0	2.44	2.73
Silvex		1	4.0	0.50	0.56
Sodium chlorate		1	4.0	0.05	0.05
TCA		1	4.0	4.00	4.48
Toxaphene		6	24.0	13.45	15.07
Trifluralin	Treflan	2	8.0	0.63	0.70
MICHIGAN, 54 SITES					
Aldrin		1	1.8	2.00	2.24
Atrazine	AAtrex	14	25.9	2.00	2.24
Captan		1	1.8	5.00	5.60
Carbaryl		1	1.8	1.00	1.12
2,4-D		1	1.8	1.00	1.12
Demeton		1	1.8	3.00	3.36
Endosulfan		1	1.8	6.00	6.72
EPTC	Eptam	3	5.5	1.67	1.86
Fentin hydroxide		1	1.8	2.25	2.52
Isodrin		1	1.8	0.01	0.01
Lead arsenate		1	1.8	16.00	17.93
Mancozeb	Dithane M-45	1	1.8	12.00	13.44
Parathion, ethyl		2	3.7	3.50	3.92
Phosalone		1	1.8	4.00	4.48
Prolate	Imidan	2	3.7	11.60	13.00
Pyrazon	Pyramin	1	1.8	1.25	1.40
Silvex		1	1.8	0.50	0.56
TCA		1	1.8	1.00	1.12
TEPP		1	1.8	4.00	4.48
MID-ATLANTIC,[3] 16 SITES					
Alachlor	Lasso	1	6.2	2.00	2.24
Atrazine	AAtrex	4	25.0	0.94	1.05
Butylate	Sutan	2	12.5	1.63	1.82
Captan		2	12.5	0.01	0.01
Carbofuran	Furadan	1	6.2	1.00	1.12
2,4-D		1	6.2	0.50	0.56
Diazinon		1	6.2	0.80	0.89
Malathion		2	12.5	0.01	0.01
Parathion, ethyl		1	6.2	2.00	2.24
Sulfur		1	6.2	48.00	53.79
MISSISSIPPI, 31 SITES					
Alachlor	Lasso	1	3.2	0.75	0.84
Captan		1	3.2	0.03	0.03
Chloroneb	Demosan	7	22.5	0.03	0.03
DDT		8	25.8	3.81	4.27
DEF		4	12.9	0.90	1.00
Disulfoton	Di-Syston	7	22.5	0.01	0.01
Diuron	Karmex	2	6.4	2.75	3.08
DNBP		4	12.9	1.19	1.33
DSMA		1	3.2	1.86	2.08
Endrin		1	3.2	4.20	4.70
Ethylmercury chloride	Ceresan Red	1	3.2	0.01	0.01
Fluometuron	Cotoran	5	16.1	0.76	0.85
Folex		3	9.6	0.75	0.84
Linuron	Lorox	1	3.2	1.00	1.12
Malathion		1	3.2	2.40	2.68
Methylmercury acetate	Ceresan L	6	19.3	0.01	0.01
Mirex		4	12.9	0.08	0.09
MSMA		7	22.5	2.48	2.77
Nitralin	Planavin	1	3.2	1.00	1.12
Parathion, methyl		13	41.9	3.36	3.77

(Continued next page)

TABLE 3 (cont'd.). *Compounds applied to cropland sites by state, 1971—National Soils Monitoring Program*

Compound	Trade Name, If Noted	Pesticides Applied: No. of Sites	Pesticides Applied: % of Sites	Average Total Application: lb./Acre	Average Total Application: kg/Hectare
Sodium chlorate		2	6.4	1.07	1.20
Terrazole		1	3.2	0.15	0.16
Thiram		1	3.2	0.04	0.04
Toxaphene		10	32.2	6.90	7.73
Trifluralin	Treflan	7	22.5	0.75	0.84
MISSOURI, 80 SITES					
Alachlor	Lasso	7	8.7	1.82	2.03
Aldrin		3	3.7	0.63	0.70
Atrazine	AAtrex	17	21.2	2.24	2.50
Chloramben	Amiben	2	2.5	0.88	0.98
2,4-D		2	2.5	0.50	0.56
2,4-DB	Butyrac	1	1.2	0.22	0.24
DSMA		1	1.2	3.00	3.36
Linuron	Lorox	2	2.5	0.88	0.98
MSMA		1	1.2	1.65	1.84
Naptalam	Alanap	2	2.5	2.00	2.24
Propachlor	Ramrod	3	3.7	3.13	3.51
Trifluralin	Treflan	3	3.7	0.75	0.84
NEBRASKA, 105 SITES					
Alachlor	Lasso	2	1.9	1.50	1.68
Atrazine	AAtrex	22	20.9	1.38	1.54
Bux		5	4.7	0.91	1.01
Captan		31	29.5	0.01	0.01
Carbaryl	Sevin	2	1.9	1.17	1.31
Carbofuran	Furadan	6	5.7	0.89	0.99
Chevron RE-5353		4	3.8	0.85	0.95
2,4-D		21	20.0	0.72	0.81
Diazinon		1	0.9	1.30	1.45
Dichloropropene		1	0.9	17.00	19.05
Dieldrin		2	1.9	0.01	0.01
Disulfoton	Di-Syston	1	0.9	1.00	1.12
EPTC	Eptam	1	0.9	3.00	3.36
Fensulfothion		1	0.9	0.61	0.68
Heptachlor		1	0.9	0.01	0.01
Londax		1	0.9	0.50	0.56
Malathion		26	24.7	0.03	0.03
Methoxychlor		2	1.9	0.01	0.01
Methylmercury dicyandiamide	Panogen	2	1.9	0.01	0.01
Parathion, ethyl		2	1.9	1.00	1.12
Phorate	Thimet	5	4.7	0.87	0.97
Propachlor	Ramrod	4	3.8	2.59	2.90
Thiram		1	0.9	0.01	0.01
NEW ENGLAND,[1] 18 SITES					
Alachlor	Lasso	1	5.5	2.00	2.24
Atrazine	AAtrex	1	5.5	1.00	1.12
Azinphosmethyl	Guthion	1	5.5	0.50	0.56
Carbaryl	Sevin	1	5.5	1.25	1.40
Dinitrocresol		1	5.5	0.75	0.84
Endosulfan		1	5.5	0.75	0.84
EPTC	Eptam	1	5.5	4.00	4.48
Maneb		1	5.5	4.80	5.37
Parathion, methyl		1	5.5	1.25	1.40
NEW YORK, 37 SITES					
Atrazine	AAtrex	11	29.7	1.38	1.54
Azinphosmethyl	Guthion	2	5.4	0.56	0.62
Butylate	Sutan	1	2.7	3.00	3.36
Captan		4	10.8	0.66	0.73
Carbaryl	Sevin	2	5.4	3.20	3.58
2,4-D		3	8.1	0.37	0.41
Dieldrin		2	5.4	0.25	0.28
Dinitrocresol		1	2.7	2.67	2.99
Disulfoton	Di-Syston	2	5.4	0.70	0.78
DNBP	Premerge	2	5.4	2.97	3.33
Dodine		1	2.7	0.33	0.36
Endosulfan		1	2.7	0.50	0.56
Folpet	Phaltan	1	2.7	1.00	1.12
Lead arsenate		1	2.7	4.00	4.48
Malathion		2	5.4	0.01	0.01
Mancozeb	Dithane M-45	1	2.7	12.80	14.34
Methoxychlor		1	2.7	0.01	0.01
Phosphamidon	Dimecron	1	2.7	0.50	0.56
Propargite	Omite	1	2.7	5.00	5.60
Simazine	Princep	1	2.7	2.04	2.28
Sulfur		1	2.7	0.50	0.56
NORTH CAROLINA, 30 SITES					
Alachlor	Lasso	3	10.0	3.00	3.36
Atrazine	AAtrex	7	23.3	1.86	2.08
Carbaryl	Sevin	2	6.6	3.00	3.36
2,4-D		5	16.6	2.20	2.46
DEF		1	3.3	0.75	0.84
Dichlofenthion	Nemacide	1	3.3	6.00	6.72
Dichloropropene		1	3.3	67.00	75.09
Disulfoton	Di-Syston	2	6.6	0.90	1.00
Fensulfothion		1	3.3	2.00	2.24
Fluometuron	Cotoran	1	3.3	1.25	1.40
Malathion		1	3.3	0.50	0.56
Maleic hydrazide		2	6.6	3.00	3.36
Naptalam	Alanap	1	3.3	3.00	3.36
Toxaphene		1	3.3	0.09	0.10
Trifluralin	Treflan	2	6.6	1.00	1.12
OHIO, 59 SITES					
Alachlor	Lasso	3	5.0	0.92	1.02
Aldrin		3	5.0	3.67	4.10
Atrazine	AAtrex	8	13.5	2.01	2.25
Azinphosmethyl	Guthion	1	1.6	1.00	1.12
Bordeaux mixtures		1	1.6	1.25	1.40
Captan		1	1.6	5.20	5.82
Carbaryl	Sevin	2	3.3	1.13	1.26
Carbophenothion	Trithion	1	1.6	3.20	3.58
Chloramben	Amiben	2	3.3	2.75	3.08
Chloropropham	CIPC	1	1.6	2.50	2.80
Cypromid	Clobber	1	1.6	0.75	0.84
2,4-D		12	20.3	0.50	0.56
Dicamba	Banvel D	5	8.4	0.20	0.22
Dodine		1	1.6	0.50	0.56
Ferbam		1	1.6	3.17	3.55
Heptachlor		2	3.3	1.57	1.76
Lead arsenate		1	1.6	1.20	1.34
Linuron	Lorox	4	6.7	1.25	1.40
Methoxychlor		1	1.6	2.00	2.24
Parathion, ethyl		1	1.6	0.50	0.56
Phosphamidon	Dimecron	1	1.6	0.03	0.03
Simazine		1	1.6	2.00	2.24
OKLAHOMA, 62 SITES					
Alachlor	Lasso	1	1.6	5.00	5.60
Arsenic pentoxide		2	3.2	0.50	0.56
Atrazine	AAtrex	1	1.6	13.00	14.57
Captan		2	3.2	0.01	0.01
2,4-D		3	4.8	3.08	3.45
Disulfoton		2	3.2	0.65	0.72
EMTS	Ceresan M	4	6.4	0.01	0.01
Ethylmercury chloride	Ceresan Red	1	1.6	0.01	0.01
Furethrin		1	1.6	8.00	8.96
Methylmercury dicyandiamide	Panogen	2	3.2	0.01	0.01
Nabam		1	1.6	5.00	5.60
Parathion, ethyl		3	4.8	3.17	3.54
Parathion, methyl		5	8.0	0.50	0.56
Phorate		1	1.6	15.00	16.81
Thiram		3	4.8	0.01	0.01
OREGON, 37 SITES					
Atrazine	AAtrex	1	2.7	4.00	4.48
Bromacil	Hyvar	1	2.7	0.37	0.41
Captafol	Difolatan	1	2.7	1.50	1.68
2,4-D		3	8.1	0.50	0.56
Dicamba	Banvel D	1	2.7	0.06	0.06
Dichlorprop	2,4-DP	1	2.7	3.00	3.36
Dichloropropene		1	2.7	0.01	0.01
Disulfoton	Di-Syston	2	5.4	2.00	2.24
Endosulfan	Thiodan	2	5.4	0.75	0.84
EPTC	Eptam	1	2.7	3.00	3.36
Heptachlor		1	2.7	0.01	0.01
Hexachloro-benzene		1	2.7	0.01	0.01
Linuron	Lorox	1	2.7	0.75	0.84

(Continued next page)

TABLE 3 (cont'd.). *Compounds applied to cropland sites by state, 1971—National Soils Monitoring Program*

Compound	Trade Name, If Noted	Pesticides Applied: No. of Sites	Pesticides Applied: % of Sites	Average Total Application: lb./Acre	Average Total Application: kg/Hectare
Malathion		1	2.7	1.00	1.12
Methylmercury dicyandiamide	Panogen	3	8.1	0.14	0.15
Mevinphos	Phosdrin	1	2.7	0.50	0.56
Oxydemeton-methyl	Metasystox-R	1	2.7	0.50	0.56
Parathion, ethyl		2	5.4	3.25	3.64
PENNSYLVANIA, 36 SITES					
Alachlor	Lasso	2	5.5	0.88	0.98
Atrazine	AAtrex	5	13.8	1.65	1.84
Butylate	Sutan	1	2.7	1.20	1.34
2,4-D		2	5.5	0.50	0.56
Malathion		1	2.7	1.00	1.12
Methoxychlor		1	2.7	1.00	1.12
SOUTH CAROLINA, 15 SITES					
Benefin	Balan	1	6.6	1.08	1.21
BHC		1	6.6	0.03	0.03
Carbaryl	Sevin	2	13.3	2.25	2.52
Copper sulfate		1	6.6	10.50	11.76
2,4-DB		1	6.6	0.25	0.28
DDT		3	20.0	8.94	9.24
DEF		2	13.3	1.16	1.30
Disulfoton	Di-Syston	2	13.3	0.59	0.65
Diuron	Karmex	2	13.3	1.00	1.12
Naptalam	Alanap	1	6.6	0.75	0.84
Parathion, methyl		5	33.3	4.76	5.34
Thiram		1	6.6	0.01	0.01
Toxaphene		3	20.0	13.16	14.75
Trifluralin	Treflan	2	13.3	1.00	1.12
SOUTH DAKOTA, 106 SITES					
Atrazine	AAtrex	5	4.7	1.59	1.78
Barban	Carbyne	1	0.9	0.25	0.28
Bux		3	2.8	0.70	0.78
Captan		24	22.6	0.01	0.01
2,4-D		32	30.1	0.45	0.50
Diazinon		3	2.8	1.64	1.83
Dicamba	Banvel D	2	1.8	0.12	0.13
Dieldrin		2	1.8	0.01	0.01
Ethylmercury chloride	Ceresan Red	1	0.9	0.01	0.01
Fensulfothion		1	0.9	1.20	1.34
Malathion		17	16.0	0.01	0.01
MCPA	MCP	2	1.8	0.25	0.28
Methoxychlor		1	0.9	0.01	0.01
Methylmercury dicyandiamide	Panogen	4	3.7	0.01	0.01
Parathion, methyl		1	0.9	0.50	0.56
Phorate	Thimet	1	0.9	0.60	0.67
Propachlor	Ramrod	3	2.8	2.40	2.68
Thiram		2	1.8	0.01	0.01
Atrazine	AAtrex	2	8.3	1.85	2.07
2,4-DB	Butyrac	1	4.1	0.29	0.32
DDT		1	4.1	3.00	3.36
TENNESSEE, 24 SITES					
DEF		1	4.1	1.50	1.68
Disulfoton	Di-Syston	3	12.5	3.00	3.36
Diuron	Karmex	2	8.3	1.55	1.73
DSMA		1	4.1	2.00	2.24
Fluometuron	Cotoran	2	8.3	1.50	1.68
Folex		1	4.1	1.50	1.68
Parathion, methyl		1	4.1	1.50	1.68
Sodium chlorate		1	4.1	1.50	1.68
Toxaphene		1	4.1	6.00	6.72
Trietazine		1	4.1	0.70	0.78
Trifluralin		3	12.5	0.98	1.09
VIRGINIA/WEST VIRGINIA,[1] 26 SITES					
Atrazine	AAtrex	2	7.6	2.00	2.24
Captan		1	3.8	0.08	0.08
Carbaryl	Sevin	1	3.8	2.00	2.24
Diazinon		1	3.8	0.40	0.44
Dinitrocresol		1	3.8	1.50	1.68
Endosulfan		1	3.8	1.20	1.34
EPTC	Eptam	1	3.8	0.70	0.78
Metham	Vapam	1	3.8	2.16	2.42
Methoxychlor		1	3.8	0.80	0.89
Vernolate	Vernam	1	3.8	2.00	2.24
WASHINGTON STATE, 45 SITES					
Aldrin		1	2.2	0.43	0.48
BHC		2	4.4	0.01	0.01
Bromacil		2	4.4	0.75	0.84
Captan		2	4.4	0.06	0.06
2,4-D		13	28.8	1.32	1.48
DDT		1	2.2	0.75	0.84
Dicamba	Banvel D	1	2.2	0.13	0.14
HCB		6	13.3	0.01	0.01
Methylmercury dicyandiamide		1	2.2	0.01	0.01
Parathion, ethyl		1	2.2	1.50	1.68
Phenylmercury acetate		1	2.2	0.01	0.01
Phenylmercury urea		3	6.6	0.01	0.01
Terbacil	Sinbar	1	2.2	1.40	1.56
Terbutryn	Igran	1	2.2	1.75	1.96
WISCONSIN, 66 SITES					
Alachlor	Lasso	4	6.0	1.44	1.61
Atrazine	AAtrex	25	37.8	1.83	2.04
Bux		1	1.5	7.00	7.84
Carbofuran	Furadan	3	4.5	0.90	1.01
2,4-D		2	3.0	1.50	1.68
2,4-DB	Butyrac	1	1.5	0.50	0.56
Disulfoton	Di-Syston	1	1.5	2.00	2.24
Endosulfan	Thiodan	1	1.5	1.00	1.12
Linuron	Lorox	1	1.5	1.00	1.12
MCPA	MCP	1	1.5	0.50	0.56
Phorate	Thimet	1	1.5	6.00	6.72
Thiram		1	1.5	0.01	0.01

[1] See Table 1.

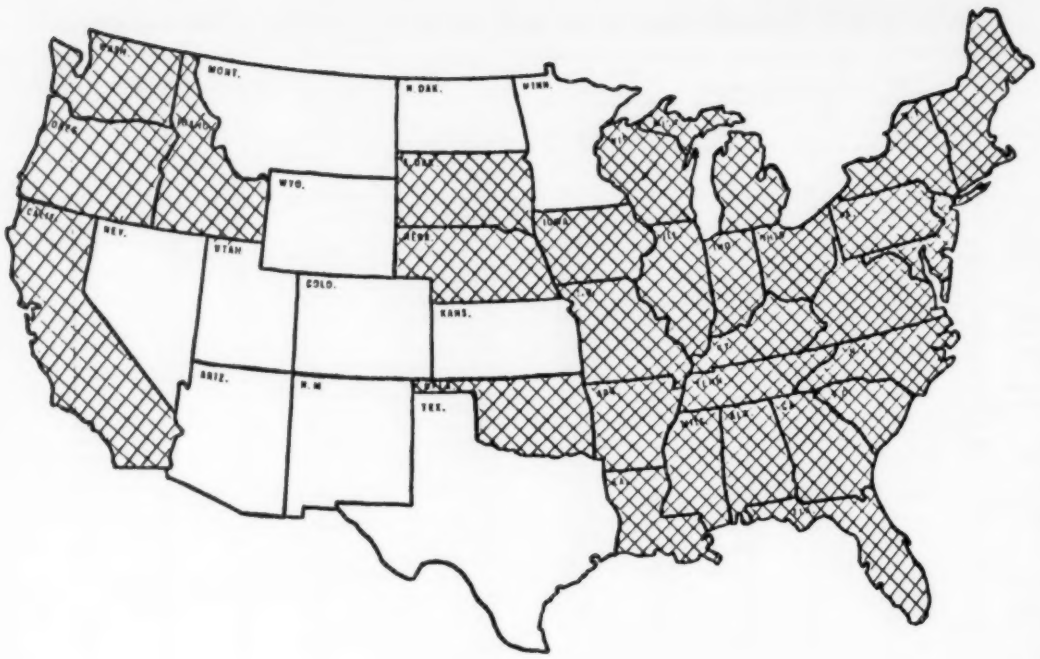

FIGURE 2. *Percent of sites reporting pesticide applications, 1971, National Soils Monitoring Program*

TABLE 4. *Crop and pesticide application data for sampling sites, 1971—National Soils Monitoring Program*

Crop	Total No. of Sites	Pesticides Applied No. of Sites	%	Pesticides Not Applied No. of Sites	%	Pesticides Application Unknown No. of Sites	%
Corn, field	445	366	82	70	16	9	2
Soybeans	251	147	59	100	40	4	1
Wheat	115	56	49	59	51		
Hay, mixed	112	3	3	108	96	1	1
Alfalfa and/or bur clover	108	10	9	97	90	1	1
Cotton	63	55	87	6	10	2	3
Sorghum, sweet sorghum, milo	52	32	62	19	37	1	1
Oats	47	16	34	30	64	1	2
Pasture	41	2	5	39	95		
Hay, grass	25			25	100		
Barley	16	4	25	12	75		
Peanuts	11	9	82			2	18
Potatoes, white	11	9	82	2	12		
Clover	9	1	11	8	89		
Rice	9	8	89	1	11		
Beans, dry	8	5	63	3	37		
Grapes	8	7	88	1	12		
Apples	7	7	100				
Oranges	7	5	71	2	29		
Sugarbeets	6	5	83	1	17		
Sugarcane	6	6	100				
Peas	5	2	40	3	60		
Rye	5			5	100		
Tobacco	5	4	80	1	20		
Safflower	3	1	33	2	67		
Almonds	2	2	100				
Blueberries	2			2	100		
Cabbage	2	2	100				
Figs	2			2	100		
Peaches	2	2	100				
Timothy	2			2	100		
Tomatoes	2						
Apricots	1	1	100				
Broccoli	1	1	100				
Carrots	1	1	100				
Cherries	1			1	100		
Cowpeas	1			1	100		
Cucumbers	1	1	100				
Flax	1			1	100		
Grapefruit	1	1	100				
Lemons	1	1	100				
Lentils	1	1	100				
Lettuce	1	1	100				
Mint	1	1	100				
Pecans	1			1	100		
Plums/prunes	1					1	100
String beans	1	1	100				
Watermelon	1	1	100				
Other	11	3	27	8	73		
Fallow sites	83	3	4	80	96		

TABLE 5. *Compounds applied to cropland sites by crop, 1971—National Soils Monitoring Program*

Compound	Pesticides Applied		Average Total Application		Reported Total Application Rate, kg/Hectare	
	No. of Sites	% of Sites	lb./Acre	kg/Hectare	Min.	Max.
ALFALFA and BUR CLOVER, 106 SITES						
Carbaryl	1	0.9	1.00	1.12	—	1.12
Diazinon	1	0.9	0.40	0.45	—	0.45
EPTC	2	1.9	1.85	2.07	0.78	3.36
Malathion	3	2.8	1.13	1.27	1.12	1.57
Methoxychlor	2	1.9	0.90	1.01	0.90	1.12
Mevinphos	2	1.9	1.50	1.68	1.12	2.24
Parathion, ethyl	3	2.8	2.50	2.80	0.56	6.72
Trichlorfon	1	0.9	0.75	0.84	—	0.84
COTTON, 61 SITES						
Aldrin	1	1.6	0.01	0.01	0.01	
Arsenic pentoxide	2	3.3	0.50	0.56	0.56	0.56
Azodrin	4	6.6	0.33	0.37	0.06	0.56
Cacodylic acid	1	1.6	0.01	0.01	0.01	
Captan	1	1.6	0.01	0.01	0.01	
Chloroneb	9	14.8	0.01	0.01	0.01	0.01
2,4-D	1	1.6	0.44	0.49	0.49	
DDT	25	41.0	4.28	4.80	0.09	13.45
DEF	9	14.8	1.03	1.16	0.67	1.68
Dicofol	1	1.6	1.00	1.12	1.12	
Disulfoton	14	23.0	1.31	1.46	0.01	7.85
Diuron	8	13.1	1.45	1.63	0.38	5.04
DNBP	2	3.3	1.62	1.82	1.12	2.52
DSMA	11	18.0	2.00	2.24	0.24	4.48
EMTS	4	6.6	0.04	0.04	0.01	0.11
Endrin	2	3.3	2.80	3.14	1.57	4.71
Ethylmercury chloride	1	1.6	0.01	0.01	0.01	
Fluometuron	21	34.4	0.96	1.07	0.56	2.24
Folex	5	8.2	1.05	1.18	0.84	1.68
Linuron	2	3.3	0.63	0.70	0.56	0.84
Malathion	2	3.3	1.55	1.74	0.78	2.69
MCPA	1	1.6	0.50	0.56	0.56	
Mercury	2	3.3	0.06	0.07	0.01	0.12
Methyl trithion	1	1.6	3.00	3.36	3.36	
Methylmercury acetate	6	9.8	0.01	0.01	0.01	0.01
Methylmercury dicyandiamide	2	3.3	0.01	0.01	0.01	0.01
Mirex[1]	1	1.6	0.01	0.01	0.01	
Monuron	2	3.3	1.30	1.46	1.12	1.79
MSMA	15	24.6	1.86	2.08	0.75	5.60
Nitralin	1	1.6	1.00	1.12	1.12	
Paraquat	1	1.6	0.25	0.28	0.28	
Parathion, ethyl	5	8.2	6.78	7.60	0.84	21.02
Parathion, methyl	36	59.0	3.26	3.65	0.06	11.21
PCNB	2	3.3	3.51	3.93	0.01	7.85
Prometryn	2	3.3	1.08	1.21	0.18	2.24
Sodium chlorate	4	6.6	1.80	2.02	0.06	5.60
Terrazole	1	1.6	0.15	0.17	0.17	
Thiram	3	4.9	0.01	0.01	0.01	0.01
Toxaphene	27	44.3	7.95	8.91	0.10	40.35
Trifluralin	21	34.4	0.74	0.83	0.28	1.24
FIELD CORN, 427 SITES						
Alachlor	37	8.7	1.66	1.86	0.28	6.72
Aldrin	37	8.7	1.37	1.54	0.11	5.60
Atrazine	199	46.6	1.72	1.93	0.16	4.48
Butylate	18	4.2	1.74	1.95	0.28	3.36
Bux	17	4.0	1.26	1.41	0.50	7.85
Captan	116	27.2	0.01	0.01	0.01	0.01
Carbaryl	3	0.7	1.32	1.47	0.84	1.79
Carbofuran	18	4.2	0.81	0.90	0.28	2.58
Chevron RE-5353	4	0.9	0.85	0.95	0.78	1.12
Chloramben	2	0.5	1.12	1.26	0.28	2.24
Chlordane	1	0.2	2.50	2.80	2.80	
Cypromid	1	0.2	0.75	0.84	0.84	
2,4-D	72	16.9	0.73	0.81	0.06	3.36
Dalapon	2	0.5	1.05	1.18	1.18	1.18
DDT	2	0.5	1.00	1.12	1.12	1.12
Demeton	1	0.2	0.12	0.13	0.13	
Diazinon	11	2.6	0.93	1.05	0.01	2.80
Dicamba	9	2.1	0.37	0.42	0.13	1.12
Dieldrin	3	0.7	0.01	0.01	0.01	0.01
DNBP	1	0.2	3.20	3.59	3.59	
Disulfoton	2	0.5	0.65	0.73	0.56	0.90
Dyfonate	1	0.2	0.90	1.01	1.01	
EPTC	1	0.2	2.00	2.24	2.24	
Ethoprop	1	0.2	1.00	1.12	1.12	

(*Continued next page*)

TABLE 5 (cont'd.). *Compounds applied to cropland sites by crop, 1971—National Soils Monitoring Program*

Compound	Pesticides Applied		Average Total Application		Reported Total Application Rate, kg/Hectare	
	No. of Sites	% of Sites	lb./Acre	kg/Hectare	Min.	Max.
Ethylmercury chloride	1	0.2	0.01	0.01	0.01	
Fensulfothion	4	0.9	0.93	1.04	0.68	1.34
Ferbam	1	0.2	2.00	2.24	2.24	
Furethrin	1	0.2	8.00	8.97	8.97	
Heptachlor	6	1.4	1.67	1.87	0.01	3.36
Isodrin	1	0.2	0.01	0.01	0.01	
Lindane	1	0.2	0.02	0.02	0.02	
Linuron	2	0.5	0.52	0.59	0.33	0.84
Londax	1	0.2	0.50	0.56	0.56	
Malathion	96	22.5	0.01	0.01	0.01	0.01
Methoxychlor	20	4.7	0.01	0.01	0.01	0.02
Mirex[1]	1	0.2	0.01	0.01	0.01	
MSMA	1	0.2	0.25	0.28	0.28	
Paraquat	1	0.2	1.00	1.12	1.12	
Parathion, ethyl	3	0.7	0.87	0.97	0.56	1.23
PCP	1	0.2	6.00	6.72	6.72	
Phorate	20	4.7	0.81	0.91	0.19	16.81
Propachlor	38	8.9	1.42	1.57	0.10	6.72
Silvex	2	0.5	0.38	0.42	0.28	0.56
Simazine	5	1.2	2.00	2.24	1.40	2.80
2,4,5-T	2	0.5	0.30	0.34	0.28	0.39
Thiram	1	0.2	0.01	0.01	0.01	
Toxaphene	1	0.2	2.73	3.06	3.06	
MIXED HAY, 111 SITES						
2,4-D	2	1.8	0.80	0.90	0.67	1.12
Mirex[1]	1	0.9	0.01	0.01	0.01	
SOYBEANS, 243 SITES						
Alachlor	27	11.1	1.33	1.49	0.22	6.16
Captan	3	1.2	0.04	0.04	0.01	0.08
Carbaryl	5	2.1	1.88	2.11	0.90	4.30
Chloramben	38	15.6	1.42	1.59	0.25	4.48
Chloropropham	1	0.4	2.50	2.80	2.80	
Dalapon	1	0.4	6.80	7.62	7.62	
2,4-DB	6	2.5	0.84	0.94	0.25	2.19
DDT	2	0.8	2.50	2.80	1.12	4.48
Dichloropropene	1	0.4	67.00	75.09	75.09	
DNBP	10	4.1	1.08	1.21	0.43	2.52
Fluometuron	1	0.4	1.00	1.12	1.12	
Linuron	16	6.6	0.96	1.08	0.28	2.24
Mirex[1]	1	0.4	0.01	0.01	0.01	
MSMA	1	0.4	2.00	2.24	2.24	
Naptalam	3	1.2	2.33	2.61	1.12	3.36
Nitralin	4	1.6	1.06	1.19	0.84	1.68
Paraquat	1	0.4	2.00	2.24	2.24	
Parathion, methyl	3	1.2	2.55	2.86	1.12	5.77
Propachlor	1	0.4	2.80	3.14	3.14	
Solan	1	0.4	1.00	1.12	1.12	
Thiram	1	0.4	0.04	0.04	0.04	
Toxaphene	2	0.8	3.82	4.29	2.24	6.33
Trifluralin	38	15.6	1.11	1.24	0.25	5.60
Vernolate	3	1.2	0.80	0.90	0.78	1.01
WHEAT, 113 SITES						
Aldrin	1	0.9	0.01	0.01	0.01	
Azinphosmethyl	1	0.9	0.22	0.25	0.25	
Barban	1	0.9	0.25	0.28	0.28	
BHC	2	1.8	0.02	0.02	0.01	0.02
Bromacil	2	1.8	0.56	0.63	0.41	0.84
Captan	1	0.9	0.25	0.28	0.28	
2,4-D	28	24.8	0.83	0.93	0.13	4.48
Dicamba	3	2.7	0.11	0.12	0.07	0.15
Dichlorprop	1	0.9	3.00	3.36	3.00	
Disulfoton	2	1.8	0.36	0.40	0.40	0.40
EMTS	4	3.5	0.01	0.01	0.01	0.01
Ethylmercury chloride	4	3.5	0.06	0.06	0.01	0.11
Hexachlorobenzene	6	5.3	0.02	0.02	0.01	0.03
Methylmercury dicyandiamide	9	8.0	0.01	0.01	0.01	0.01
Parathion, ethyl	1	0.9	8.00	8.97	8.97	
Parathion, methyl	4	3.5	0.50	0.56	0.56	0.56
Phenylmercury acetate	3	2.7	0.01	0.01	0.01	0.01
Terbutryne	1	0.9	1.75	1.96	1.96	
Thiram	2	1.8	0.01	0.01	0.01	0.01

[1] Aerially applied for control of the imported fire ant.

TABLE 6. *Pesticide application information on selected crops, by state, for sampling sites, 1971—National Soils Monitoring Program*

State	Total No. of Sites	Pesticides Applied	Pesticides Not Applied	Pesticides Use Unknown	Total No. of Sites	Pesticides Applied	Pesticides Not Applied	Pesticides Use Unknown
	ALFALFA AND/OR BUR CLOVER				COTTON			
Alabama	0				4	4		
Arkansas	1		1		9	7	1	1
California	5	3	2		7	6	1	
Georgia	0				5	5		
Illinois	4		4		0			
Indiana	1		1		0			
Iowa	19		19		0			
Louisiana	0				7	7		
Michigan	7	1	6		0			
Mississippi	0				13	12	1	
Missouri	3	1	2		1	1		
Nebraska	10		10		0			
New England	2		2		0			
New York	4		4		0			
N. Carolina	0				1	1		
Ohio	2		2		0			
Oklahoma	2	1	1		5	2	2	1
Oregon	5	1	4		0			
Pennsylvania	7	1	5	1	0			
S. Carolina	0				5	4	1	
S. Dakota	16		16		0			
Tennessee	0				6	6		
Va./W. Va.	2	2			0			
Washington state	2		2		0			
Wisconsin	16		16		0			
	FIELD CORN				SOYBEANS			
Alabama	5	3	2		7	1	6	
Arkansas	1		1		24	13	11	
California	1		1		0			
Florida	1		1		2		2	
Georgia	13	5	8		3	2	1	
Illinois	67	65	2		58	36	22	
Indiana	34	31	2	1	21	17	3	1
Iowa	81	70	11		42	34	8	
Kentucky	16	10	4	2	3	1	1	1
Louisiana	1		1		5	2	3	
Michigan	21	14	7		1		1	
Mid-Atlantic	9	5	2	2	1	1		
Mississippi	1	1			14	9	5	
Missouri	18	16	2		22	13	8	1
Nebraska	46	40	4	2	3		3	
New England	3	2	1		0			
New York	15	11	2	2	0			
N. Carolina	13	9	4		8	5	3	
Ohio	23	19	4		14	8	5	1
Oklahoma	3	2	1		2		1	1
Pennsylvania	8	5	3		1		1	
S. Carolina	2		1	1	7	2	5	
S. Dakota	27	26	1		1	1		
Tennessee	5	2	3		9	2	7	
Va./W. Va.	3	3			1		1	
Washington state	2	1	1		0			
Wisconsin	24	23	1		0			
	WHEAT				MIXED HAY			
Alabama	0				1		1	
Arkansas	1		1		2		2	
California	4	1	3		1		1	
Florida	0				1		1	
Idaho	13	5	8		0			
Illinois	6	1	5		1		1	
Indiana	5	1	4		2		2	
Iowa	1		1		5		5	
Kentucky	0				2		2	
Michigan	1		1		9	1	8	
Mid-Atlantic	0				1		1	
Mississippi	0				1	1		
Missouri	1		1		20		20	
Nebraska	3	1	2		0			
New England	0				5		5	
New York	0				9		8	1
N. Carolina	0				1		1	
Ohio	5	1	4		6		6	
Oklahoma	34	13	21		0			
Oregon	3	3			3		3	

(Continued next page)

TABLE 6 (cont'd.). *Pesticide application information on selected crops, by state, for sampling sites, 1971—National Soils Monitoring Program*

	Total No. of Sites	Pesticides Applied	Pesticides Not Applied	Pesticides Use Known	Total No. of Sites	Pesticides Applied	Pesticides Not Applied	Pesticides Use Known
Pennsylvania	0				13	1	12	
S. Dakota	20	15	5		8		8	
Va./W. Va.	0				5		5	
Washington state	18	15	3		1		1	
Wisconsin	0				15		15	

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(*2*) *Carey, A. E., J. A. Gowen, H. Tai, W. G. Mitchell, and G. B. Wiersma. 1978.* Pesticide residue levels in soils and crops, 1971—National Soils Monitoring Program (III). Pestic. Monit. J. 12(3):117–136.

(*3*) *Panel on Pesticide Monitoring. 1971.* Criteria for defining pesticide levels to be considered an alert to potential problems. Pestic. Monit. J. 5(1):36.

(*4*) *Wiersma, G. B., P. F. Sand, and E. L. Cox. 1971.* A sampling design to determine pesticide residue levels in soils of the conterminous United States. Pestic. Monit. J. 5(1):63–66.

WATER

Organochlorines, Cholinesterase Inhibitors, and Aromatic Amines in Dutch Water Samples, September 1969–December 1975

Ronald C. C. Wegman and Peter A. Greve [1]

ABSTRACT

The Dutch aquatic environment was monitored from September 1969 to December 1975 for organochlorine pesticides and their metabolites, cholinesterase inhibitors, and aromatic amines. The 1,492 samples analyzed included surface water, rainwater, groundwater, and drinking water.

The highest concentrations of hexachlorobenzene (HCB) and α- and β-benzene hexachloride (BHC) were found in the Rhine River and its tributaries. Concentrations of the compounds in the Dutch part of the Rhine River decreased downstream. Other organochlorine pesticides and their metabolites, heptachlor, heptachlor epoxide, aldrin, dieldrin, endrin α- and β-endosulfan, and ΣDDT were detected occasionally, but only in low concentrations. Cholinesterase inhibitors and aromatic amines were always present in the Rhine River and its tributaries.

Introduction

Preliminary investigations before 1969 of organochlorine pesticides and related substances in the Dutch aquatic environment indicated the necessity of a long-term investigation. Endosulfan levels found in the Rhine River later in 1968 (*6*) underlined the need for such an investigation.

Samples were taken from surface water, rainwater, groundwater, and drinking water prepared from surface water. Presently, about one third of the Dutch population is at least partly supplied with drinking water prepared from surface water. Sampling sites varied every year, except for a few fixed sites including the Maas and Rhine Rivers, so that after 7 years all parts of The Netherlands were investigated for at least 1 year. Special interest was paid to large agricultural areas such as the IJsselmeerpolders.

During the study, the number of sampling sites at drinking water stations was gradually decreased as the stations acquired equipment and expertise to analyze their own samples.

Levels of organochlorine pesticides were determined because they are persistent and accumulate in the food chain. Analyses were performed for cholinesterase inhibitors including phosphates, thiophosphates, dithiophosphates, and carbamates (e.g., dichlorvos, parathion, malathion, carbaryl, respectively). From the herbicide group, urea compounds were chosen because of their great application rate. This group of compounds was determined as their aromatic amine moiety.

During the present investigation, papers were published on endosulfan in the Rhine River (*6*), cholinesterase inhibitors in Dutch surface waters (*8*), pesticides in the Rhine River (*9*), aromatic amines and their derivatives in Dutch surface waters (*10*), and the fate of pesticides during drinking water preparation (*7*). In cooperation with the Federal Health Office in Berlin, the concentrations of cholinesterase inhibitors in the German and Dutch parts of the Rhine River were compared and the main source was determined (*5*). From these papers, only the primary results are repeated here.

Methods and Materials

The 1,492 samples were collected by means of a bail and were transported in acetone-washed bottles to the National Institute of Public Health, Bilthoven, The Netherlands. Surface water was taken from a depth of about 1 m. Locations of the 92 sampling sites are given in Figure 1.

The methods mentioned in the present report include improvements introduced during the study. They had no

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FIGURE 1. *Sampling sites for study of organochlorines, cholinesterase inhibitors, and aromatic amines in Dutch water samples*

significant influence on the results, except for the C_6 compounds which could be determined separately only from May 1970.

ORGANOCHLORINE COMPOUNDS

Water samples of 1000 ml, including silt, were extracted successively with 200, 100, and 100 ml of petroleum ether (boiling range, 40°–60°C). The combined extracts were dried over anhydrous sodium sulfate and concentrated to about 5 ml in a Kuderna-Danish evaporative concentrator. The last few milliliters of solvent were evaporated to exactly 1 ml by a gentle stream of nitrogen at room temperature. The concentrated extract was added to a microcolumn containing 2.00 g basic alumina (W-200, activity Super I, Woelm). Before use, the microcolumn was activated for 16 hours at 150°C, and then deactivated with 11 percent water (11 g water + 89 g alumina).

The column was eluted with 5 ml of petroleum ether to produce Eluate A containing HCB, α- and γ-BHC, heptachlor epoxide (about 10 percent), *p,p'*-DDE, *o,p'*-DDT, TDE, *p,p'*-DDT, telodrin, isodrin, aldrin, and heptachlor. The receiving tube was changed and a

second elution was carried out with 10 ml of a 20:80 (v/v) mixture of ethyl ether–petroleum ether to produce Eluate B containing β-BHC, heptachlor epoxide (about 90 percent), dieldrin, and endrin. The eluates were concentrated to exactly 1 ml by a gentle stream of nitrogen at room temperature.

To determine α- and β-endosulfan, a microcolumn containing 2.00 g 60–200-mesh silica gel (Fisher S 661) activated for 2–3 hours at 140°C was used. The column was eluted first with 8 ml of a 80:20 (v/v) mixture of hexane–toluene and next with 8 ml of a 40:60 (v/v) mixture of hexane–toluene and 8 ml toluene; α- and β-endosulfan were present in the second eluate. One-μl portions of the concentrated eluates were injected into the gas chromatographs. Instrument parameters and operating conditions follow:

(1) Model 1800 Varian Aerograph

Detector:	tritium electron-capture
Column:	180 cm × 0.3 cm ID Pyrex, packed with a mixture of 5 percent OV-210 and 5 percent OV-17 (4+1) on 80–100-mesh Chromosorb W-HP
Temperatures:	injection port 205°C oven 190°C detector 200°C
Carrier gas:	nitrogen flowing at 40 ml/minute

(2) Perkin-Elmer Model F 22 gas chromatograph

Detector:	^{63}Ni electron-capture
Column:	40 m × 0.35 mm ID Pyrex capillary, coated with SE-30 (GC grade)
Temperatures:	injection port 215°C oven 155°–225°C at 3°C/minute with a linear temperature programmer detector 250°C
Carrier gas:	helium flowing at 2–3 ml/minute; helium splitting gas flow of 0–60 ml/minute; nitrogen purge gas flow of 80 ml/minute

The practical lower limit of detectability was 0.01 ppb. Recovery data, obtained by spiking river water samples with the pesticides and carrying them through the entire analytical procedure, were over 90 percent. Results are not corrected for recovery. To confirm the identity of the pesticides, *p*-values or chemical conversions were used, such as the quantitative conversion of *o,p'*-DDT and *p,p'*-DDT to, respectively, *o,p'*-DDE and *p,p'*-DDE by treatment with MgO, the disappearance of dieldrin and endrin by treatment with concentrated sulfuric acid, and the peak shift for endosulfan under the influence of alkali (*6*).

AROMATIC AMINES

The sums of aromatic amines and their derivatives were determined colorimetrically (*10*). Concentrations are expressed as 3,4-dichloroaniline. The practical lower limit of detectability was 0.5 ppb.

CHOLINESTERASE INHIBITORS

Colorimetric determination of cholinesterase inhibitors was performed in a methylene chloride extract of the sample on an AutoAnalyzer (*9*). The enzyme source was freeze-dried human plasma. Concentrations were calculated as paraoxon equivalents. The practical lower limit of detection was 0.2 ppb.

Results

The 20,000 data points collected in the monitoring program during 1969–75 are summarized in Tables 1–7. In view of the low frequency of occurrence and the low concentrations found, the concentrations of β-BHC, aldrin, heptachlor, heptachlor epoxide, endrin, TDE, *o,p'*-DDT, *p,p'*-DDE, and *p,p'*-DDT are not given in the tables. Unless stated otherwise, all extracts of water samples included silt.

The Rhine River was studied in more detail than the other Dutch surface waters. Samples were taken weekly near Lobith at sampling site 45 (Fig. 1). The geographical distribution of HCB, and α- and γ-BHC in the Rhine River is illustrated in Figures 2–4 for the southern branch of the river, Rhine–Boven Merwede–Nieuwe Waterweg.

Discussion

The data in Tables 1–7 indicate that the highest concentrations of pesticides and related substances are found in the Rhine River and its tributaries. The highest concentrations in the Maas River, compared below, are much lower.

Pesticide	Residue, ppb	
	Rhine River	Maas River
HCB	0.55	0.29
α-BHC	0.60	0.07
γ-BHC	0.42	0.18
Dieldrin	0.06	0.03
Endosulfan	0.81	0.09
Cholinesterase inhibitors	56	1.7
Aromatic amines	10	2.4

Levels in other waters were lower still or not detected.

HCB and α- and γ-BHC were almost always present in the Rhine water samples. Median values in ppb varied during 1969–75 as follows: HCB, 0.06–0.14; α-BHC, 0.06–0.22; and γ-BHC, 0.04–0.13. Concentrations of the by-product, α-BHC, are higher than those of the commercial product, γ-BHC. This means either that significant amounts of α-BHC-containing products, which have been banned for years, are still used along the Rhine or that industry, rather than agriculture, is the main source of pollution. Because the source of contamination is located across the German border, it was not possible to determine the exact source of the BHC discharge. BHC has had only limited use as a fungicide. Since July 1974, the concentrations of α- and γ-BHC in the Rhine have decreased considerably. Median values of α- and γ-BHC in 1974 were 0.22 ppb and 0.13 ppb, respectively; in 1975, 0.06 ppb and 0.04 ppb, respectively. The levels of α-BHC in the Rhine and its tributaries are considered harmful to the reproduction of *Daphnia magna* (water flea) (*3*).

TABLE 1. *Concentrations of BHC, dieldrin, endosulfan, and cholinesterase inhibitors in Dutch samples, 1969*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb							
				γ-BHC		Dieldrin		α- and β-Endosulfan		Cholinesterase Inhibitors[1]	
				Max	Med	Max	Med	Max	Med	Max	Med
Surface water for drinking water preparation											
Braakman	1	raw water	2	—	—	0.01	—	—	—		
Berenplaat	2	raw water	4	0.16	0.06	0.01	—	0.03	—	3.02	1.03
Berenplaat	2	treated water	4	0.02	—	0.01	—	—	—	0.17	0.17
Drentse A	3	raw water	3	—	—	—	—	—	—		
Loenerveense Plas	4	raw water	3	—	—	0.01	0.01	—	—		
Wantij	6	raw water	3	0.09	0.05	0.01	—	0.11	0.09	5.20	1.82
IJsselmeer, Andijk	7	raw water	4	—	—	0.04	—	0.01	—		
IJsselmeer, Andijk	7	treated water	4	—	—	0.04	—	0.01	—		
Surface water for infiltration											
Amsterdam-Rijnkanaal	8	raw water	2	0.02	0.01	—	—	0.17	0.14	1.42	1.06
Amsterdam-Rijnkanaal	8	raw water[2]	1	—	—	—	—	0.06	0.06	1.20	1.20
Lek	9	raw water	2	0.03	0.02	—	—	0.10	0.09	1.38	1.09
Lek	9	raw water[2]	1	—	—	—	—	—	—	1.52	1.52
Enschede	10	raw water[3]	3	0.15	0.02	0.01	—	—	—	0.05	0.05
St. Jansteen	11	raw water	3	—	—	0.02	0.01	—	—		
St. Jansteen	11	treated water	1	0.01	0.01	0.03	0.03	0.03	0.03		
Valkenburgse Watering	15	raw water	4	0.03	0.02	0.02	—	0.05	—	0.32	0.22
IJsselmeer region											
IJsselmeer, Staveren	25	surface water	1	0.03	0.03	—	—	—	—		
IJsselmeer, Y-2	27	surface water	1	—	—	—	—	—	—		
IJsselmeer, Steile Bank	28	surface water	1	0.02	0.02	—	—	—	—		
Maas and tributaries											
Maas, Eijsden	35	surface water	7	0.08	0.02	—	—	0.09	—	0.44	0.22
Roer	42	surface water	2	0.02	0.01	0.01	—	—	—		
Niers	43	surface water	3	0.11	0.03	0.02	0.01	0.13	0.06	0.19	0.18
Rhine and tributaries											
Rhine	45	surface water	17	0.24	0.18	0.04	—	0.81	0.24	10.67	2.46
Kromme Rijn	47	surface water	6	0.08	0.02	0.02	—	0.04	—	2.04	1.00
Other surface waters											
Oostermoerse Vaart	57	surface water	4	0.01	—	0.02	—	—	—		
Boomawetering	76	surface water	8	0.09	—	0.02	0.01	0.01	—	0.57	0.42
Rijnbeek	82	surface water	4	—	—	0.01	—	—	—	0.52	0.52
Lage Vaart, Colijn	85	surface water	12	0.05	—	0.06	0.01	0.09	—		
Hoge Vaart, Colijn	86	surface water	24	0.08	—	0.08	—	0.10	—		
Lage Vaart, Wortman	89	surface water	29	0.10	—	0.14	—	0.09	—		
Larser Vaart	90	surface water	13	—	—	0.08	0.02	—	—		
Wortmanvaart	92	surface water	12	—	—	0.03	0.01	—	—		

NOTE: β-BHC, aldrin, heptachlor, heptachlor epoxide, endrin, and ΣDDT were detected occasionally in low concentrations; — = not detected. Unless stated otherwise, all water samples included silt.

[1] As paraoxon-equivalents.

[2] After rapid filtration.

[3] Before infiltration.

TABLE 2. *Concentrations of HCB, BHC, dieldrin, endosulfan, and cholinesterase inhibitors in Dutch water samples, 1970*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb											
				HCB		α-BHC		γ-BHC		Dieldrin		α- and β-Endosulfan		Cholinesterase Inhibitors[1]	
				Max	Med	Max	Med	Max	Med	Max	Med	Max	Med	Max	Med
Surface water for drinking water preparation															
Braakman	1	raw water	2	0.02	—	0.02	0.01	0.02	0.01	0.02	0.01	0.03	—	—	—
Berenplaat	2	raw water	2	—	—	0.17	0.12	0.09	0.07	0.03	—	0.07	—	0.80	0.30
Drentse A	3	raw water	2	—	—	—	—	0.02	0.01	—	—	0.02	—	0.18	0.06
Loenerveense Plas	4	raw water	1	—	—	—	—	—	—	—	—	0.03	—	—	—
Oud-Beijerland	5	raw water	2	0.03	—	0.17	0.12	0.06	0.05	0.01	—	0.12	—	1.08	0.83
Oud-Beijerland	5	treated water	2	0.01	—	0.13	0.09	0.07	0.06	0.02	—	0.04	—	0.79	0.50
Wantij	6	raw water	3	0.08	0.05	0.18	0.15	0.12	0.11	—	—	0.04	—	2.00	0.63
Wantij	6	treated water	2	0.01	—	0.06	0.06	0.05	0.05	0.02	—	0.03	—	0.45	0.20
IJsselmeer, Andijk	7	raw water	3	—	—	0.02	0.02	0.02	0.01	0.01	—	0.07	—	0.27	0.06
IJsselmeer, Andijk	7	treated water	3	—	—	0.02	0.01	0.02	0.01	0.02	—	0.05	—	0.17	0.07
Surface water for infiltration															
Amsterdam-Rijnkanaal	8	raw water	3	0.05	0.03	0.13	0.08	0.13	0.08	0.01	—	0.05	—	0.82	0.52
Amsterdam-Rijnkanaal	8	raw water[2]	3	0.03	0.02	0.15	0.10	0.18	0.11	0.01	0.01	0.04	—	0.82	0.42
Lek	9	raw water	3	0.04	0.02	0.16	0.08	0.20	0.10	0.02	0.01	0.07	—	1.10	0.36
Lek	9	raw water[2]	3	0.03	0.02	0.17	0.10	0.20	0.11	0.01	—	0.05	—	1.05	0.40
Enschede	10	raw water[3]	3	—	—	0.50	0.32	0.05	0.02	0.02	0.02	0.05	—	0.07	0.06
Enschede	10	raw water[2]	3	—	—	0.14	0.12	—	—	0.01	—	0.04	—	—	—
St. Jansteen	11	raw water	3	0.01	—	0.01	—	0.01	—	0.02	—	0.03	—	—	—
Valkenburgse Watering	15	raw water	6	—	—	—	—	—	—	0.01	—	0.03	—	0.75	0.34
Groundwater															
Bilthoven	18	groundwater	2	—	—	—	—	—	—	—	—	—	—	—	—
Coastal waters															
Waddenzee	22	surface water	3	—	—	0.01	—	0.01	—	0.01	—	0.10	—	0.15	0.08
IJsselmeer region															
IJsselmeer, Y-1	26	surface water	2	0.01	—	0.03	0.02	0.04	0.03	0.01	—	0.05	0.02	0.34	0.21
Ketelmeer, Y-14	31	surface water	1	0.02	0.02	0.23	0.23	0.13	0.13	—	—	0.04	0.02	0.63	0.49
IJsselmeer, Y-104	34	surface water	2	0.01	—	0.03	0.03	0.04	0.04	0.01	—	0.01	—	0.24	0.22
Maas and tributaries															
Maas, Eysden	35	surface water	8	0.04	—	0.03	—	0.06	0.02	0.01	—	0.03	—	0.50	0.22
Roer	42	surface water	5	0.02	—	0.02	0.01	0.05	0.04	0.01	—	0.03	—	0.12	0.06
Niers	43	surface water	6	0.01	—	0.06	0.02	0.05	0.03	0.01	—	0.04	—	0.11	0.06
Rhine and tributaries															
Rhine	45	surface water	51	0.39	0.08	0.26	0.14	0.16	0.08	0.04	—	0.40	0.03	4.01	0.72
Kromme Rijn	47	surface water	6	0.02	—	0.15	0.05	0.11	0.05	0.03	—	0.03	—	2.08	0.40
Other surface waters															
Ruiten A	52	surface water	5	0.01	—	—	—	—	—	0.01	—	0.02	—	0.10	0.05
Overijsselse Vecht	60	surface water	4	—	—	—	—	—	—	0.01	—	0.03	—	0.09	—
ditch, A.Paulowna	68	surface water	5	—	—	0.01	—	—	—	0.02	0.01	—	—	0.33	0.10
ditch, Hillegom	69	surface water	2	—	—	0.03	0.02	0.01	—	—	—	—	—	0.22	0.18
ditch, Hillegom	70	surface water	2	—	—	0.04	0.02	0.01	—	0.04	0.04	—	—	0.37	0.18
ditch, Hillegom	71	surface water	2	—	—	0.01	—	—	—	—	—	—	—	0.34	0.17
ditch, Hoogeveen	72	surface water	2	—	—	—	—	—	—	0.02	0.01	—	—	0.32	0.22
Leidse Vaart, Lisse	73	surface water	2	—	—	—	—	0.02	0.02	0.03	0.02	—	—	0.26	0.16
ditch, Noordwijkerhout	74	surface water	2	0.01	—	—	—	—	—	0.08	0.06	—	—	0.21	0.10
Leidse Vaart, De Zilk	75	surface water	2	—	—	0.01	—	0.05	0.02	0.04	0.03	—	—	0.22	0.16
Boomawetering	76	surface water	5	—	—	0.03	0.01	0.04	0.02	0.03	—	0.15	0.01	0.40	0.12
Rijnbeek	82	surface water	6	0.01	—	0.02	—	0.03	0.01	0.01	—	0.05	0.03	0.53	0.10
Lage Vaart, Colijn	85	surface water	5	—	—	0.02	0.01	0.02	0.01	0.02	0.01	0.02	—	0.23	0.06
Hoge Vaart, Colijn	86	surface water	5	0.01	—	0.06	0.02	0.04	0.02	0.02	0.01	0.02	0.01	0.24	
Lage Vaart, De Block van Kuffeler	87	surface water	5	0.04	—	0.02	0.01	0.03	0.02	0.03	0.01	0.04	—	0.11	0.05
ditch, N.O.polder	91	surface water	1	—	—	—	—	—	—	0.07	0.07	0.07	0.07	0.14	0.14
Wortman	92	surface water	5	0.01	0.01	0.03	0.02	0.03	0.03	0.01	—	0.03	—	0.13	0.12

NOTE: See NOTE, Table 1.
[1] As paraoxon-equivalents.
[2] After rapid filtration.
[3] Before infiltration.

TABLE 3. *Concentrations of HCB, BHC, dieldrin, endosulfan, and cholinesterase inhibitors in Dutch water samples, 1971*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb											
				HCB		α-BHC		γ-BHC		Dieldrin		α- and β-Endosulfan		Cholinesterase Inhibitors[1]	
				Max	Med	Max	Med	Max	Med	Max	Med	Max	Med	Max	Med
Surface water for drinking water preparation															
IJsselmeer	7	raw water	12	0.01	—	0.13	0.02	0.20	0.03	0.03	—	—	—	0.20	0.08
Surface water for infiltration															
Enschede	10	raw water[2]	5	—	—	0.15	0.06	0.03	0.01	0.02	—	—	—	—	—
Enschede	10	raw water[3]	5	—	—	0.38	0.06	0.02	—	0.03	—	—	—	—	—
Valkenburgse Watering	15	raw water	6	0.01	—	0.03	0.02	0.08	0.02	—	—	0.02	—	1.18	0.40
Groundwater															
Bilthoven	18	groundwater	1	—	—	—	—	—	—	—	—	—	—	—	—
Haarlem	19	groundwater	1	0.01	0.01	—	—	—	—	—	—	—	—	—	—
Hillegom	20	groundwater	1	—	—	—	—	—	—	—	—	—	—	—	—
IJsselmeer region															
Ketelmeer, Y-14	31	surface water	8	0.01	—	0.13	0.05	0.10	0.03	0.03	0.01	0.01	—	0.40	0.19
Ketelhaven	32	surface water	9	0.03	0.02	0.18	0.12	0.14	0.06	0.06	—	0.04	—	1.26	0.33
Maas and tributaries															
Maas, Eysden	35	surface water	10	0.05	0.01	0.01	0.01	0.03	0.01	0.03	—	—	—	0.25	0.08
Maas, Urmond	36	surface water	2	0.02	0.01	—	—	0.01	—	0.05	0.04	0.01	—	0.08	0.04
Maas, Maasbracht	37	surface water	6	0.01	—	0.01	0.01	0.12	0.01	0.02	0.01	—	—	0.20	—
Maas, Kessel	38	surface water	6	0.01	—	0.01	—	0.13	—	0.03	0.02	0.07	—	0.18	—
Roer	42	surface water	6	0.01	—	0.02	0.01	0.02	0.01	0.02	—	0.02	—	0.12	0.08
Niers	43	surface water	5	0.01	—	0.08	0.02	0.03	0.02	0.06	—	0.02	—	0.08	0.08
Rhine and tributaries															
Rhine	45	surface water	52	0.52	0.14	0.48	0.16	0.34	0.10	0.06	—	0.25	—	2.00	0.16
Other surface waters															
Winschoterdiep	51	surface water	5											0.56	0.12
Bagmolenbeek	58	surface water	1	—	—	0.06	0.06	0.02	0.02	—	—	—	—	0.74	0.38
Regge	63	surface water	3											0.14	0.12
Twentekanaal, Almelo	64	surface water	3	—	—	0.01	0.01	0.01	—	0.02	0.02	—	—	0.50	0.46
Twentekanaal, bovenpand	65	surface water	3	—	—	0.13	0.10	0.20	0.01	—	—	—	—	—	—
Lage Vaart, Colijn	85	surface water	6	0.01	—	0.04	0.01	0.02	0.01	0.02	—	—	—	0.40	0.09
Hoge Vaart, Colijn	86	surface water	6	—	—	0.08	0.04	0.05	0.04	0.02	—	—	—	0.46	0.23
Lage Vaart, Wortman	89	surface water	6	—	—	0.03	0.02	0.02	0.01	0.04	—	0.03	—	0.32	—

NOTE: See NOTE, Table 1.
[1] As paraoxon-equivalents.
[2] Before infiltration.
[3] After rapid filtration.

TABLE 4. *Concentrations of HCB, BHC, dieldrin, endosulfan, and cholinesterase inhibitors in Dutch water samples, 1972*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb											
				HCB		α-BHC		γ-BHC		Dieldrin		α- and β-Endosulfan		Cholinesterase Inhibitors[1]	
				Max	Med	Max	Med	Max	Med	Max	Med	Max	Med	Max	Med
Surface water for drinking water preparation															
IJsselmeer, Andijk	7	raw water	12	0.01	—	0.05	0.02	0.04	0.02	0.05	—	0.01	—	0.44	0.24
Surface water for infiltration															
Enschede	10	raw water[2]	6	0.01	—	0.17	0.10	0.02	0.02	0.05	—	—	—	—	—
Enschede	10	raw water[3]	6	0.01	—	0.09	0.06	0.01	0.01	—	—	—	—	—	—
Valkenburgse Watering	15	raw water	9	0.03	—	0.04	0.02	0.03	0.02	0.02	—	—	—	3.52	0.76
Rainwater															
Bilthoven	17	rainwater	8	0.01	—	0.50	0.02	0.06	0.02	0.01	—	—	—	—	—
IJsselmeer region															
IJsselmeer, Y-2	27	surface water	11	0.01	—	0.05	0.02	0.05	0.03	0.02	—	—	—	0.42	0.13
IJsselmeer, Y-2	27	surface water[2]	4	0.03	—	0.04	0.03	0.03	0.02	0.02	—	—	—		
IJsselmeer, Y-10	29	surface water	11	0.05	—	0.25	0.03	0.20	0.03	0.03	—	—	—	1.10	0.25
IJsselmeer, Y-10	29	surface water[2]	4	0.02	0.01	0.24	0.06	0.20	0.05	0.02	—	—	—		
IJsselmeer, Y-12	30	surface water	11	0.20	0.01	0.20	0.07	0.20	0.05	0.02	—	—	—	2.44	0.48
IJsselmeer, Y-12	30	surface water[2]	4	0.03	0.01	0.12	0.12	0.13	0.08	0.04	0.02	—	—		
Ketelhaven	32	surface water	11	0.08	0.04	0.20	0.12	0.22	0.10	0.02	—	—	—	1.18	0.76
Ketelhaven	32	surface water[2]	4	0.04	—	0.16	0.09	0.19	0.14	0.02	—	—	—		
IJsselmeer, Y-20	33	surface water	11	0.06	0.01	0.08	0.02	0.08	0.03	0.03	—	—	—	1.94	0.17
IJsselmeer, Y-20	33	surface water[3]	4	0.01	—	0.02	0.02	0.03	0.02	0.05	0.02	—	—		
Maas and tributaries															
Maas, Eijsden	35	surface water	11	0.03	0.01	0.07	0.01	0.07	0.02	0.01	—	—	—	0.44	—
Maas, Grave	39	surface water	12	0.02	—	0.08	0.01	0.13	0.02	0.01	—	0.01	—	0.14	—
Maas, Keizersveer	41	surface water	12	0.01	—	0.06	0.01	0.18	0.02	0.02	—	0.01	—	0.16	0.07
Roer	42	surface water	12	0.01	—	0.09	—	0.04	0.02	0.02	—	0.01	—	0.50	—
Niers	43	surface water	12	0.08	0.01	0.15	0.08	0.06	0.04	0.08	—	0.09	—	0.12	—
Dieze	44	surface water	10	0.05	—	0.06	0.01	0.07	0.03	0.02	—	0.02	—	0.32	0.14
Rhine and tributaries															
Rhine	45	surface water	52	0.37	0.13	0.57	0.16	0.28	0.11	0.02	—	0.03	—	2.36	0.73
Other surface waters															
Zuidlaardermeer	53	surface water	6	0.01	—	0.01	—	0.01	—	0.01	—	—	—	0.12	—
Lauwersmeer	54	surface water	6	0.03	—	0.01	—	0.01	—	0.01	—	—	—	—	—
Van Starkenborghkanaal	55	surface water	6	0.03	—	0.02	—	0.02	0.01	0.01	—	—	—	—	—
Meppelerdiep	56	surface water	6	0.02	—	0.02	—	0.02	—	0.01	—	—	—	—	—
Regge, bovenloop	61	surface water	3											0.22	0.07
Regge, benedenloop	62	surface water	3	0.02	0.02	0.11	0.06	0.05	0.04	0.01	—	—	—	0.11	—
Twentekanaal, bovenpand	65	surface water	2	—	—	0.44	0.22	0.02	0.01	0.01	—	—	—	0.06	—
Eem	66	surface water	6	0.01	—	0.08	0.05	0.06	0.04	0.01	—	—	—	1.72	0.17
Vecht	67	surface water	6	0.01	—	0.06	0.03	0.05	0.02	—	—	—	—	0.64	0.06
Lage Vaart, Colijn	85	surface water	7	0.01	—	0.01	—	0.02	0.01	0.03	—	—	—	0.06	—
Hoge Vaart, Colijn	86	surface water	7	0.01	—	0.08	0.02	0.09	0.01	0.01	—	—	—	0.52	0.06
Lage Vaart, De Block van Kuffeler	87	surface water	7	0.03	—	0.01	—	0.02	—	—	—	—	—	—	—
Hoge Vaart, De Block van Kuffeler	88	surface water	7	0.01	—	0.03	0.01	0.04	0.02	0.01	—	—	—	0.14	—
Lage Vaart, Wortman	89	surface water	7	0.01	—	0.01	0.01	0.02	0.02	0.01	—	—	—	0.36	

NOTE: See NOTE, Table 1.
[1] As paraoxon-equivalents.
[2] Before infiltration.
[3] After rapid filtration.

TABLE 5. *Concentrations of HCB, BHC, dieldrin, endosulfan, and cholinesterase inhibitors in Dutch water samples, 1973*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb											
				HCB		α-BHC		γ-BHC		Dieldrin		α- and β-Endosulfan		Cholinesterase Inhibitors[1]	
				Max	Med	Max	Med	Max	Med	Max	Med	Max	Med	Max	Med
Surface water for drinking water preparation															
IJsselmeer, Andijk	7	raw water	9	0.01	—	0.10	0.03	0.08	0.03	—	—	0.01	—	1.10	0.12
Surface water for infiltration															
Enschede	10	raw water[2]	6	—	—	0.09	0.04	—	—	—	—	—	—	1.90	—
Rainwater															
Bilthoven	17	rainwater	13	—	—	0.03	0.01	0.05	0.02	0.02	—	—	—		
Coastal waters															
Bocht van Watum	21	surface water	3	—	—	0.01	—	0.05	0.01	—	—	—	—	0.06	—
Westerschelde, Schaar van Ouden Doel	23	surface water	13	0.03	0.01	0.10	0.01	0.12	0.04	0.01	—	—	—	0.68	0.32
Westerschelde, Hansweert	24	surface water	13	0.07	—	0.03	—	0.14	0.03	0.01	—	—	—	0.60	0.08
IJsselmeer region															
IJsselmeer, Y-2	27	surface water	12	0.01	—	0.14	0.04	0.13	0.03	—	—	—	—	2.64	0.20
IJsselmeer, Y-10	29	surface water	13	0.01	—	0.10	0.05	0.06	0.04	—	—	—	—	1.65	0.50
Ketelhaven	32	surface water	11	0.08	0.02	0.23	0.10	0.19	0.09	—	—	0.07	—	5.10	1.88
Maas and tributaries															
Maas, Eijsden	35	surface water	13	0.29	0.01	0.02	0.01	0.05	0.01	—	—	0.01	—	1.65	0.06
Maas, Grave	39	surface water	12	0.03	0.01	0.19	0.02	0.12	0.02	—	—	—	—	1.26	—
Maas, Keizersveer	41	surface water	13	0.04	0.01	0.02	0.01	0.06	0.02	—	—	—	—	1.62	0.06
Roer	42	surface water	1									—	—		
Niers	43	surface water	1									—	—		
Dieze	44	surface water	1									—	—		
Rhine and tributaries															
Rhine	45	surface water	52	0.55	0.08	0.45	0.19	0.42	0.12	0.02	—	0.10	—	15.80	2.42
Boven Merwede	48	surface water	24	0.10	0.03	0.36	0.15	0.23	0.11	0.01	—	0.02	—	4.40	1.46
Nieuwe Waterweg	50	surface water	13	0.06	0.02	0.35	0.13	0.21	0.09	0.01	—	0.01	—	4.45	1.24
Other surface waters															
Twentekanaal, Almelo	64	surface water	5	—	—	0.03	0.01	0.01	0.01	—	—	0.01	—	0.60	—
Twentekanaal, bovenpand															
Roosendaalse Vliet	81	surface water	1	0.01	—	—	—	—	—	—	—	—	—	0.18	0.06
Hoge Vaart, Colijn	86	surface water	6	0.01	—	0.09	—	0.07	—	—	—	0.01	—	1.16	0.25
Hoge Vaart, De Block van Kuffeler	88	surface water	6	0.01	—	0.02	—	0.01	—	—	—	0.01	—	—	—

NOTE: See NOTE, Table 1.
[1] As paraoxon-equivalents.
[2] After rapid filtration.

TABLE 6. *Concentrations of HCB, BHC, dieldrin, endosulfan, cholinesterase inhibitors, and aromatic amines in Dutch water sample, 1974*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb: HCB Max	HCB Med	α-BHC Max	α-BHC Med	γ-BHC Max	γ-BHC Med	Dieldrin Max	Dieldrin Med	α- and β-Endosulfan Max	α- and β-Endosulfan Med	Cholinesterase Inhibitors[1] Max	Cholinesterase Inhibitors[1] Med	Aromatic Amines[2] Max	Aromatic Amines[2] Med
Surface water for drinking water preparation																	
Enschede	10	surface water[3]	5	0.01	—	0.15	0.07	0.02	—								
Isabella Wetering	12	surface water	5	—	—	0.01	—	0.03	0.01	—	—	—	—	—	—	—	—
Pieters v.d.Endevaart	13	surface water	6	—	—	0.01	—	0.01	—	0.01	—	—	—	—	—	—	—
canal near Valkenburg	14	raw water	6	—	—	0.11	0.06	0.08	0.04					1.32	0.05	1.0	—
Wijde A	16	raw water	6	—	—	0.22	0.07	0.09	0.05					1.54	0.26	1.8	0.5
Rainwater																	
Bilthoven	17	rainwater	12	—	—	0.08	0.02	0.10	0.04	—	—						
Coastal waters																	
Bocht van Watum	21	surface water	5	—	—	0.01	0.01	0.05	0.01					1.60	—	0.8	—
IJsselmeer region																	
IJsselmeer, Y-10	29	surface water	12	0.01	—	0.12	0.06	0.10	0.04					1.36	0.70	4.6	0.8
Ketelhaven	32	surface water	11	0.09	0.04	0.57	0.14	0.26	0.07					3.34	0.56	15	3.4
Maas and tributaries																	
Maas, Eijsden	35	surface water	12	0.05	0.01	0.02	0.01	0.04	0.02					0.50	—	0.8	—
Maas, Keizersveer	41	surface water	13	0.02	—	0.03	0.01	0.05	0.02					1.64	0.12	1.0	—
Rhine and tributaries																	
Rhine	45	surface water	50	0.39	0.10	0.60	0.22	0.33	0.13	0.05	—	0.02	—	3.64	1.36	8.6	4.5
Boven Merwede	48	surface water	12	0.12	0.06	0.55	0.28	0.26	0.12					3.36	0.79	16	3.8
Hollandse IJssel	49	surface water	6	0.01	—	0.10	0.03	0.05	0.04					1.16	0.09	1.0	0.6
Nieuwe Waterweg	50	surface water	11	0.05	0.03	0.36	0.21	0.23	0.11					2.40	0.60	5.8	2.6
Other surface waters																	
Twentekanaal, bovenpand	65	surface water	7	0.05	—	2.1	0.58	0.12	0.05					0.83	—	—	—
ditch, Ouddorp	78	surface water	6	0.01	—	0.01	—	0.01	—					1.60	—	3.7	—
Gentse Vaart	79	surface water	6	0.01	—	0.01	—	0.02	0.01	—	—			0.12	—	0.7	—
Roosendaalse Vliet	81	surface water	6	—	—	0.01	—	0.02	0.01					0.05	—	—	—
Zwarte Water I	83	surface water	6	—	—	0.01	0.01	0.16	0.01	0.06	—			0.10	—	8.1	—
Zwarte Water II	84	surface water	6	—	—	0.09	0.02	0.04	0.02	—	—			—	—	3.0	0.6
Hoge Vaart, Colijn	86	surface water	6	0.02	—	0.14	0.01	0.10	—					0.58	—	4.4	0.7
Hoge Vaart, De Block van Kuffeler	88	surface water	6	0.01	—	0.02	0.01	0.03	—					—	—	1.0	

NOTE: See NOTE, Table 1.
[1] As paraoxon-equivalents.
[2] As 3,4-dichloroaniline-equivalents.
[3] Before infiltration.

TABLE 7. *Concentrations of HCB, BHC, dieldrin, endosulfan, cholinesterase inhibitors, and aromatic amines in Dutch water samples, 1975*

Sampling Site	No.	Types of Water	No. of Samples	Residues, ppb: HCB Max	HCB Med	α-BHC Max	α-BHC Med	γ-BHC Max	γ-BHC Med	Dieldrin Max	Dieldrin Med	α- and β-Endosulfan Max	α- and β-Endosulfan Med	Cholinesterase Inhibitors[1] Max	Cholinesterase Inhibitors[1] Med	Aromatic Amines[2] Max	Aromatic Amines[2] Med
Rainwater																	
Bilthoven	17	rainwater	10	0.01	—	0.03	0.02	0.04	0.03	—	—						
Maas and tributaries																	
Maas, Eijsden	35	surface water	13	0.02	—	0.01	0.01	0.03	0.02					0.44	—	1.5	0.6
Maas, Lith	40	surface water	13	0.02	—	0.03	0.01	0.07	0.02					0.18	—	2.4	0.7
Rhine and tributaries																	
Rhine	45	surface water	44	0.21	0.06	0.21	0.06	0.14	0.04	0.02	—	0.02	—	56.0	7.80	10	3.7
IJssel	46	surface water	11	0.06	0.03	0.09	0.03	0.06	0.03					21.0	8.70	14	2.8
Boven Merwede	48	surface water	12	0.10	0.03	0.13	0.05	0.07	0.03					18.0	7.20	9.5	3.8
Nieuwe Waterweg	50	surface water	12	0.02	0.01	0.09	0.04	0.09	0.03					10.0	6.00	4.0	2.6
Other surface waters																	
Overijsselse Vecht	59	surface water	6											0.12	—		
Twentekanaal, Almelo	64	surface water	5	—	—	0.06	0.04	0.04	0.02					0.04	—	1.9	0.7
Twentekanaal, bovenpand	65	surface water	6	0.01	—	1.40	0.47	0.04	0.04					2.10	—	1.0	0.6
polder ditch	77	surface water	6	—	—	0.02	—	0.01	—					—	—	0.5	—
Grote Kreek	80	surface water	6	—	—	0.02	0.01	0.02	0.01	—	—			0.34	—	0.7	—
Zwarte Water I	83	surface water	6	0.01	—	0.01	—	0.02	0.01	—	—			—	—	1.4	—
Zwarte Water II	84	surface water	6	0.08	—	0.30	0.04	0.09	0.02	—	—			0.14	—	6.8	2.3

NOTE: See NOTE, Table 1.
[1] As paraoxon-equivalents.
[2] As 3,4-dichloroaniline-equivalents.

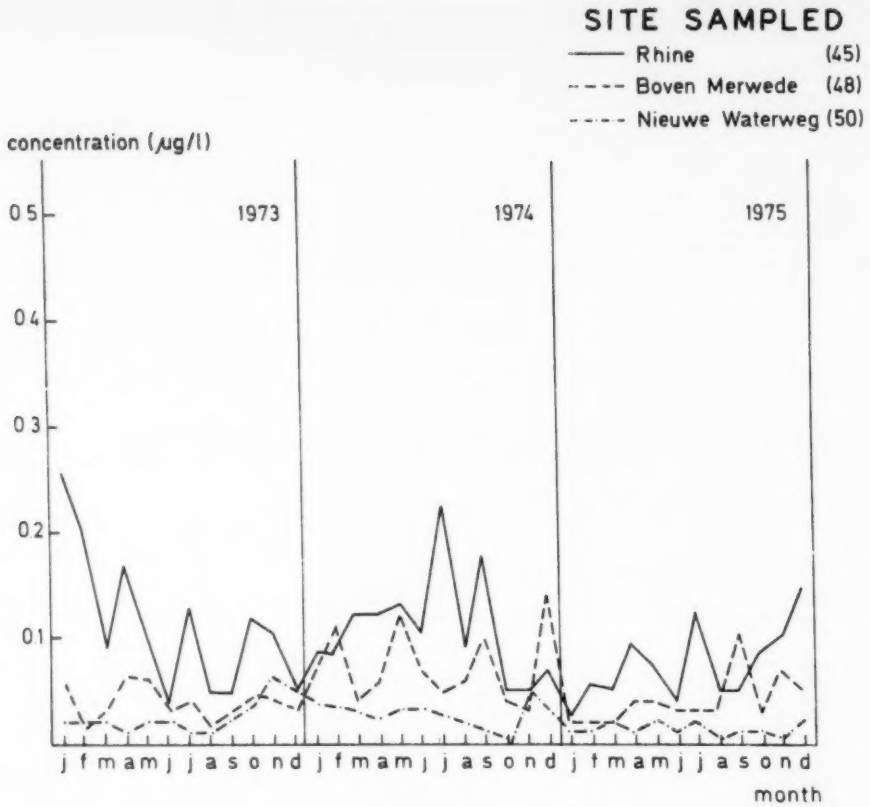
SITE SAMPLED
Rhine (45)
Boven Merwede (48)
Nieuwe Waterweg (50)
concentration (µg/l)
0 5
0 4
0 3
0 2
0 1
1973
1974
1975
j f m a m j j a s o n d j f m a m j j a s o n d j f m a m j j a s o n d
month

FIGURE 2. *Concentrations of HCB in the southern region of the Rhine River (sites 45, 48, and 50 in Fig. 1)*

High concentrations of α-BHC were also found in the Twentekanaal. The source of the contamination was a chemical plant which produces γ-BHC. The α-BHC, a worthless by-product of the synthesis of γ-BHC, was dumped beside the canal. Removal of the dumped material led to a gradual decrease of concentrations in the canal and in drinking water removed from canal water.

Concentrations of HCB have also decreased, but gradually and less drastically (Figs. 2–4). HCB is a low-polarity compound which is volatile with water and readily adsorbed by the solid particles which settle in fluvial transport.

Concentrations of cholinesterase inhibitors have gradually increased since 1972 and significantly in 1975. Concentrations of α- and β-endosulfan have decreased greatly following the first sensational wave in June–July 1969 (*9*) and a second, less important one in autumn of the same year.

In Table 8, maximum and median or mean concentrations of α-BHC, γ-BHC, ΣBHC, dieldrin, ΣDDT, and DDE from nine nations are summarized (*1, 2, 4, 12–23*). Levels of α- and γ-BHC, ΣBHC, dieldrin, ΣDDT, and DDE in Dutch surface waters are of the same order of magnitude as are the concentrations in other industrialized countries. Concentrations of aromatic amines are comparable in Dutch and German parts of the Rhine River (*11*).

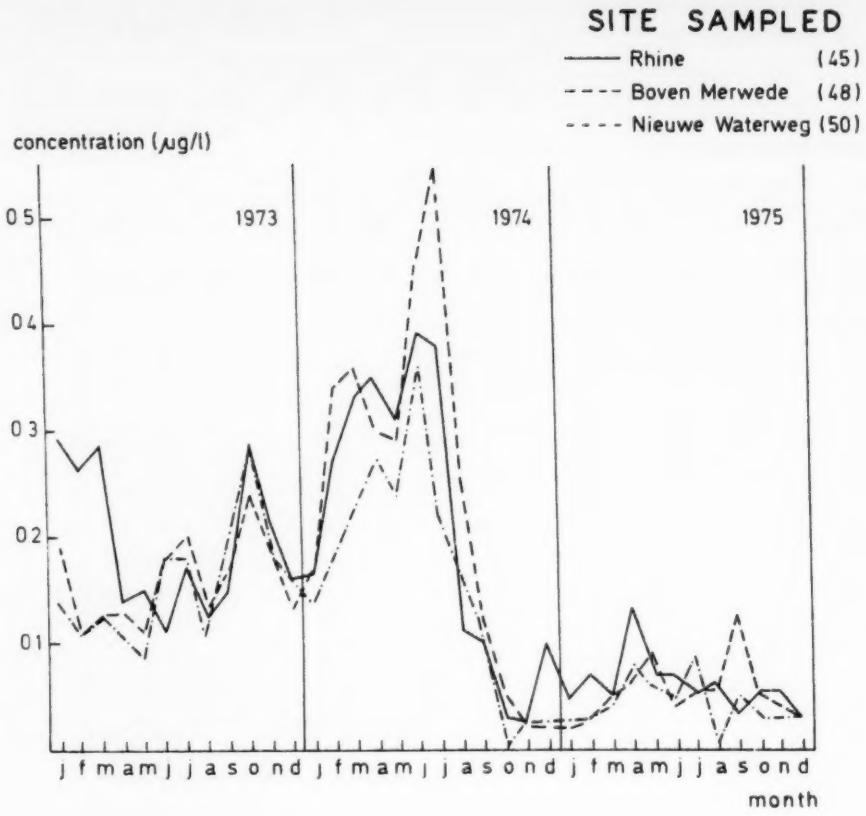
SITE SAMPLED
Rhine (45)
Boven Merwede (48)
Nieuwe Waterweg (50)
concentration (µg/l)
0 5
0 4
0 3
0 2
0 1
1973
1974
1975
j f m a m j j a s o n d j f m a m j j a s o n d j f m a m j j a s o n d
month

FIGURE 3. *Concentrations of α-BHC in the southern region of the Rhine River (sites 45, 48, and 50 in Fig. 1)*

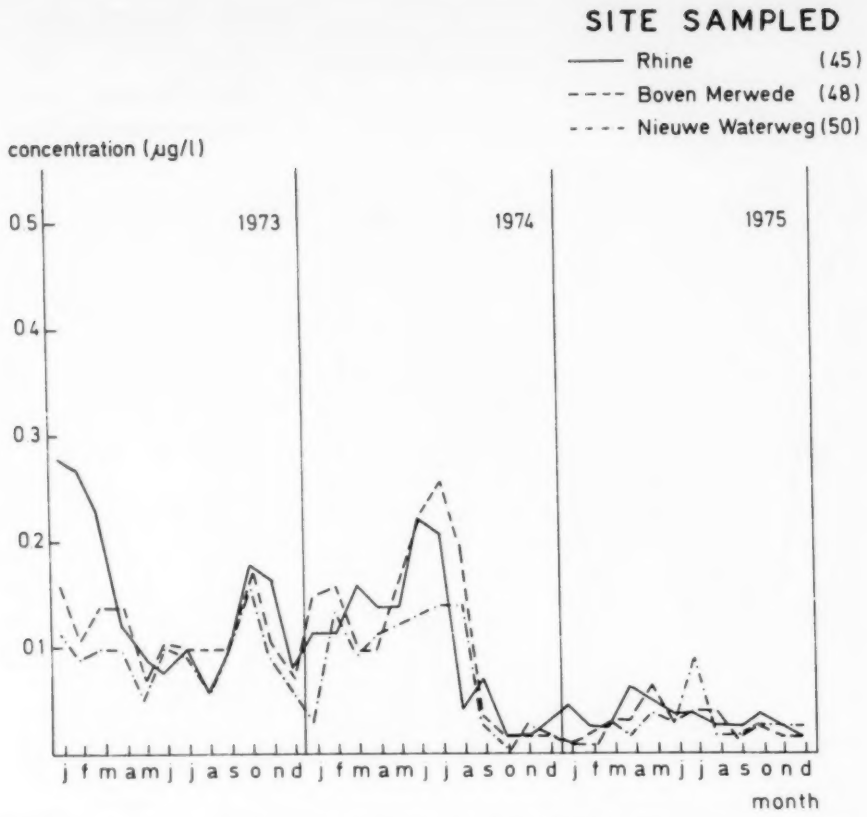
SITE SAMPLED
Rhine (45)
Boven Merwede (48)
Nieuwe Waterweg (50)
concentration (µg/l)
0 5
0 4
0 3
0 2
0 1
1973
1974
1975
j f m a m j j a s o n d j f m a m j j a s o n d j f m a m j j a s o n d
month

FIGURE 4. *Concentrations of γ-BHC in the southern region of the Rhine River (sites 45, 48, and 50 in Fig. 1)*

TABLE 8. *Concentrations of organochlorine pesticides in worldwide surface waters, 1968–75*

Location	No. of Sites	Types of Water	Residues, ppb												Literature References
			α-BHC		γ-BHC		ΣBHC		Dieldrin		DDT		DDE		
			Max	Med	Max	Med	Max	Med	Max	Med	Max	Med	Max	Med	
Brazil	9	surface water					4	<1			<1	<1			Lara and Barreto, 1972 (*15*)
Canada	3	surface water	—	—[1]	—	—[1]			0.04	0.01[1]	0.07	0.01[1]	0.01	—[1]	Miles and Harris, 1973 (*16*)
Czechoslovakia	150	surface water 1971–72	0.52		0.81						0.60				Uhnáh et al., 1974 (*23*)
Federal Republic of Germany (FRG)	8	surface water 1970	1.90	0.10[1]	7.10	0.10[1]			0.04	—[1]	0.25	—[1]			Herzel, 1972 (*12*)
	27	surface water 1971	2.40	0.07[1]	1.75	0.17[1]			—	—[1]	0.84	—[1]			Herzel, 1972 (*12*)
German Democratic Republic (GDR)	26	surface water			0.67	0.15					3.2	0.34	0.98	0.15	Engst and Knoll, 1973 (*4*)
Japan	130	river water 1970–73			3.43	0.20	14.15	0.92							Suzuki et al., 1974 (*21*)
Hungary	4	Balaton Lake 1973			0.04	0.04[1]					0.01	—[1]	—[1]	—[1]	Pásztor et al., 1975 (*18*)
Netherlands	16	surface water 1969					0.24	—[1]	0.14	—[1]	0.20	—[1]	0.16	—[1]	the present report
	26	surface water 1970	0.50	0.03[1]	0.20	0.05[1]			0.08	—	0.11	—[1]	—	—[1]	
	17	surface water 1971	0.48	0.04[1]	0.34	0.03[1]			0.06	—[1]	0.11	—[1]	—	—[1]	
	26	surface water 1972	0.57	0.04[1]	0.28	0.03[1]			0.08	—[1]	0.17	—[1]	0.15	—[1]	
	21	surface water 1973	0.45	0.07	0.42	0.04[1]			0.02	—	0.11	—	0.01	—	
	17	surface water 1974	0.60	0.17	0.33	0.07			0.06	—	0.04	—	0.01	—	
	13	surface water 1975	1.40	0.03	0.14	0.03			0.02	—	0.03	—	0.01	—	
United States of America		Utah Lake 1970–71					1.3				4.1				Bradshaw et al., 1972 (*1*)
	1	Mississippi River 1974			—	—			0.01	—					Brodtmann, 1976 (*2*)
	6	Iowa Rivers 1968							0.01	—	0.01	—	0.01	—	Johnson and Morris, 1971 (*13*)
	10	Iowa Rivers 1969							0.06	—	0.01	—	0.01	—	
	10	Iowa Rivers 1970							0.06	—	0.02	—	0.02	—	
	1	Des Moines River Iowa 1971							0.05	0.03					Kellog and Bulkley, 1976 (*14*)
		Iowa 1972							0.04	—					
		Iowa 1973							0.02	0.01					
	10	Iowa rivers 1968							0.01		0.01		0.01		Morris et al., 1972 (*17*)
	10	Iowa rivers 1969							0.06		0.02		0.01		
	10	Iowa rivers 1970							0.06		0.02		0.02		
	10	Iowa rivers 1971							0.04		0.22		0.03		
	19	surface water 1974							0.07				3.92		Richard et al., 1975 (*19*)
	20	rivers 1968			0.07				0.03		0.46		0.10		Schulze et al., 1973 (*20*)
		rivers 1969			0.04				0.02		0.05		0.06		
		rivers 1970			0.16				0.02		0.09		0.05		
		rivers 1971			0.05				0.01		0.09		0.08		
	4	streams 1969							0.33	—	2.50	0.01	0.71	—	Truhlar and Reed, 1975 (*22*)
	4	streams 1970							0.16	—	11.0	0.02	0.21	—	
	4	streams 1971							—	—	0.12	—	0.05	—	

[1] Mean value.

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BRIEF

Organochlorine Pesticide Levels in Ottawa Drinking Water, 1976

David T. Williams, Frank M. Benoit, Edward E. McNeil, and Rein Otson[1]

ABSTRACT

Duplicate samples of Ottawa drinking water were collected once a month during 1976 and analyzed for organochlorine pesticides. The samples were analyzed by gas chromatography–mass spectrometry, and pesticides were identified by comparing their retention times, coupled with selected ion monitoring, with those of known standards. The pesticides detected and their mean concentrations in parts per trillion were aldrin (0.9), heptachlor epoxide (3), heptachlor (0.6), α-BHC (6), γ-BHC (3), endrin (4), dieldrin (1), o,p′-TDE (1), o,p′-DDT (3), and o,p′-DDE (0.2).

Introduction

Ottawa drinking water was monitored for organochlorine pesticides by a simple new method using Amberlite XAD-2 macroreticular resin for the analysis of potable water at the parts per trillion (ppt) level.

Sampling and Analysis

In 1976, duplicate 200-liter samples per month, except July, of Ottawa drinking water was passed through Amberlite XAD-2 macroreticular resin during a 10-day period according to the procedure of McNeil et al. (*1*). The resin was eluted with 250 ml hexane, and the eluates were dried with sodium sulfate and concentrated to 1 ml. The concentrated hexane eluates were then analyzed with a Finnigan Model 4000 gas chromatograph–mass spectrometer coupled to a Model 6000 Data System with the following instrument parameters and operating conditions:

Column:	1.8 m × 2 mm ID glass, packed with 3 percent OV-17 on 80–100-mesh Chromosorb 750
Temperatures:	oven from 200°C (0.1 minute hold) to 250°C (hold) at 5°C/minute; injection port 225°C
Carrier gas:	helium flowing at 25 ml/minute

The mass spectrometer, operating in the selected ion mode, was programmed to monitor four ions (m/q 66, 81, 100, 109) for the first 4 minutes and four other ions (m/q 67, 79, 235, 246) for 10 minutes more. Analyses were performed on a standard pesticide mixture, including the 10 pesticides detected under identical GC–MS conditions to permit identification and quantitation. The lower limit of detection was about 0.1 ppt of pesticide in the original 200-liter water sample.

Results and Discussion

Results of the pesticide analyses are presented in condensed form in Table 1, including the relative retention time and specific ion monitored for each pesticide.

There was no consistent seasonal trend for any of the 10 pesticides detected. The monthly pesticide values varied considerably with the mean as shown by the high standard deviations in Table 1. This is expected since the levels of many of the pesticides were close to the detection limit, and the use of selected ion monitoring, although more selective than simple gas chromatography, is still subject to interference, particularly at the trace levels found.

Authors concluded that organochlorine pesticides detected in Ottawa drinking water exist as background levels which are consistently present in trace amounts in the environment.

TABLE 1. *Organochlorine pesticide residue levels in Ottawa drinking water, 1976*

Pesticide	Selected Ion Monitored	Relative Retention Time	Range min.–max., ppt	Mean ± Std Dev.	Median
α-BHC	109	1.00	0.1–15	6±4	6
γ-BHC	109	1.30	0.4–11	3±3	2
Heptachlor	100	1.63	0.1–1	0.6±0.3	0.7
Aldrin	66	1.97	0.1–6	0.9±1	0.5
Heptachlor epoxide	81	2.70	0.2–9	3±3	1
o,p′-DDE	246	3.72	0.1–0.5	0.2±0.2	0.2
Dieldrin	79	3.77	0.1–4	1±1	0.7
o,p′-TDE	235	4.17	0.1–3	1±1	0.8
Endrin	67	4.35	1–7	4±4	4
o,p′-DDT	235	4.72	0.2–8	3±3	2

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[1] Bureau of Chemical Hazards, Environmental Health Directorate, Health and Welfare Canada, Ottawa, Ontario, Canada K1A OL2.

APPENDIX

Chemical Names of Compounds Discussed in This Issue

ALDRIN	Not less than 95% of 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene
AROCLOR 1254	PCB, approximately 54% chlorine
AROCLOR 1260	PCB, approximately 60% chlorine
BHC (BENZENE HEXACHLORIDE)	1,2,3,4,5,6-Hexachlorocyclohexane (mixture of isomers)
CARBARYL	1-Naphthyl *N*-methylcarbamate
CHLORDANE	1,2,3,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene. The technical product is a mixture of several compounds including heptachlor, chlordene, and two isomeric forms of chlordane.
DDE	Dichlorodiphenyl dichloro-ethylene (degradation product of DDT); *p,p'*-DDE: 1,1-Dichloro-2,2-bis(*p*-chlorophenyl) ethylene; *o,p'*-DDE: 1,1-Dichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethylene
DDT	Main component (*p,p'*-DDT): *α*-Bis(*p*-chlorophenyl) *β,β,β*-trichloroethane Other isomers are possible and some are present in the commercial product. *o,p'*-DDT:[1,1,1-Trichloro-2-(*o*-chlorophenyl)-2-(*p*-chlorophenyl) ethane]
DICHLORVOS	2,2-Dichlorovinyl dimethyl phosphate
DIELDRIN	Not less than 85% of 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7:8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene
ENDOSULFAN	6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin 3-oxide
ENDRIN	Hexachloroepoxyoctahydro-*endo, endo*-dimethanonaphthalene
HCB	Hexachlorobenzene
HEPTACHLOR	1,4,5,6,7.8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-*endo*-methanoindene
HEPTACHLOR EPOXIDE	1,4,5,6,7,8,8-Heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindane
ISODRIN	Hexachlorohexahydro-*exo,exo*-dimethanonaphthalene
MALATHION	S-[1,2-Bis(ethoxycarbonyl) ethyl] *O,O*-dimethyl phosphorodithioate
MIREX	1,1a,2,2,3,3a,4,5,5,5a,5b,6-Dodecachlorooctahydro-1,3,4-metheno-1*H*-cyclobuta[cd]pentalene
NONACHLOR	1,2,3,4,5,6,7,8-Nonachlor-3a,4,7,7a-tetrahydro-4,7-methanoindan
PARATHION	*O,O*-Diethyl *O-p*-nitrophenyl phosphorothioate
PCBs (POLYCHLORINATED BIPHENYLS)	Mixtures of chlorinated biphenyl compounds having various percentages of chlorine
TDE	2,2-Bis(*p*-chlorophenyl)-1,1-dichloroethane (including isomers and dehydrochlorination products)
TELODRIN	Octachlorohexahydro-4,7-methanoisobenzofuran
TOXAPHENE	Chlorinated camphene (67–69% chlorine). Product is a mixture of polychlor bicyclic terpenes with chlorinated camphenes predominating.

Information for Contributors

The *Pesticides Monitoring Journal* welcomes from all sources qualified data and interpretative information on pesticide monitoring. The publication is distributed principally to scientists, technicians, and administrators associated with pesticide monitoring, research, and other programs concerned with pesticides in the environment. Other subscribers work in agriculture, chemical manufacturing, food processing, medicine, public health, and conservation.

Articles are grouped under seven headings. Five follow the basic environmental components of the National Pesticide Monitoring Program: Pesticide Residues in People; Pesticide Residues in Water; Pesticide Residues in Soil; Pesticide Residues in Food and Feed; and Pesticide Residues in Fish, Wildlife, and Estuaries. The sixth is a general heading; the seventh encompasses briefs.

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